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HUMAN-ELEPHANT INTERACTIONS: FROM PAST TO PRESENT

EDITORS
**GEORGE E. KONIDARIS, RAN BARKAI,
VANGELIS TOURLOUKIS AND KATERINA HARVATI**

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HUMAN-ELEPHANT INTERACTIONS FROM PAST TO PRESENT: AN INTRODUCTION

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Today, the thriving human lineage occupies all continents of the world, whereas the members of the proboscidean lineage (order Proboscidea) — the African savanna and forest elephants *Loxodonta africana* and *Loxodonta cyclotis*, respectively, and the Asian elephant *Elephas maximus*— are all locally restricted and considered as threatened by extinction. The extant elephants are relics of a group that was once extremely diversified and widely distributed on all continents (apart from Antarctica and Australia), especially during Miocene and Plio-Pleistocene times (Shoshani and Tassy, 1996: figs. 34.2, 34.3). Proboscideans are some of the largest mammals that ever walked on earth, and the largest ones from the Miocene to recent times.

Humans and elephants[1] shared habitats from Palaeolithic times until recently in both the Old and New World, while in Asia and Africa, the human-elephant interactions carry on until today, following a legacy of hundreds of thousands of years. In recent decades, a significant number of Pleistocene (ca. 2.6 million years–10,000 years ago) open-air and cave sites yielding elephant bones in spatial association with lithic artifacts have been discovered. Many of them show strong and direct evidence of acquisition and processing of elephant carcasses by early humans, leading archaeologists to interpret them as "butchering sites". Indeed, elephant exploitation by humans has been proposed to have played a significant role in the diet and culture of early humans.

The nature and degree of interactions between humans and elephants is an important field in

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[1] For the sake of clarity, we would like to stress that although we use the term "Human-elephant interactions", we actually refer to all members of the order Proboscidea that have been or potentially could have been exploited by humans (or perhaps other hominins). Apart from *Loxodonta*, *Elephas*, *Palaeoloxodon* and *Mammuthus*, which are classified within the family Elephantidae, exploitation of *Stegodon* (family Stegodontidae) is reported from China (e.g., Wei et al., 2017), while *Sinomastodon* (family Gomphotheriidae) was additionally present there until the late Early Pleistocene (Wang et al., 2014). Although the butchering of the deinothere *Deinotherium* (family Deinotheriidae) in FLK North 6 (Tanzania) is questioned (Domínguez-Rodrigo et al., 2007), the genus persisted in Africa until the late Early Pleistocene; the gomphothere *Anancus* survived also in Africa until close to the Pliocene/Pleistocene boundary (Sanders et al., 2010). In North America the mastodon *Mammut* (family Mammutidae) survived until the end of the Late Pleistocene and is associated in some sites with Clovis lithics, while in others there is evidence of butchering (Fisher, 1984; Haynes and Klimowicz, 2015). In South America several gomphotheres survived until the end of the Late Pleistocene/beginning of Holocene, some of them exploited by humans (e.g., Mothè et al. 2020).

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palaeoanthropological studies since decades, but many questions remain still unanswered or partially explored, and are the focus of current discussions and debates. Some of the most debated subjects revolve around the following research questions:

- Were prehistoric hunter-gatherers actively engaged in elephant hunting? Could elephant scavenging alone be responsible for sustaining a successful diet throughout the Palaeolithic?
- What are the probable methods for elephant hunting in prehistoric times and how can recent anthropological evidence shed light on the subject?
- What would elephant hunting and processing sites look like and what kind of archaeological evidence is to be expected?
- What were the mechanisms for elephant carcass processing, skinning, defleshing and dismembering in the Palaeolithic? What kind of archaeological evidence is to be expected and how can ethnographic and recent experimental data help answer these questions?
- Were elephants a significant food resource for prehistoric hunter-gatherers and how important was elephant meat and fat in the evolution of the human lineage?
- How exactly could the exploitation of elephant carcasses have influenced the subsistence strategies and technological innovations of early *Homo*? Did it play a role in the change from scavenging to active hunting?
- How important was an elephant meat-based diet to biological developments and the nutrition of our ancestors?

In order to address the above and many other questions, to provide a forum to discuss the current state of knowledge in human-elephant interactions, and to develop cross-disciplinary collaborations, a scientific symposium was organized, entitled "Human-elephant interactions: from past to present". The symposium was held October 16–18, 2019 at the Schloss Herrenhausen in Hannover (Germany) under the auspices of the Volkswagen Foundation's "Symposia and Summer Schools Initiative", and brought together specialists from the disciplinary fields of Palaeolithic Archaeology, Palaeoanthropology, Palaeontology, Zooarchaeology, Geology, Ethnography and Nutrition Studies. The present volume represents the proceedings of the symposium and gathers most of the contributions presented there. By including a diverse array of perspectives on elephant-human interactions across the world, the volume aims to provoke renewed interest for current and further research, and build an interdisciplinary and synthetic understanding of the significance of elephants throughout human history. The volume includes 19 contributions and is divided into four thematic sections: 1) The Palaeolithic record, 2) A view of the evidence, 3) Elephants in past human nutrition, and 4) Ethnography – Human-elephant interactions in recent Africa.

Before the above sections, the volume begins with a perspective chapter by Tanner (Chapter 1), who provides important insights on ontological aspects of meat and fat harvesting among extant North American subarctic hunters. The author examines their animist practices in relation to fat, stone, bone and animal hide, and draws conclusions about how such ethnographic observations contribute to the interpretations of past human behavior.

THE PALAEOLITHIC RECORD AND A VIEW OF THE EVIDENCE

Elephant remains have been found in numerous Palaeolithic sites, both open-air and cave sites, in Europe, Asia, Africa and the Americas, associated with lithic artifacts and/or humans remains attributed to several hominin species (e.g., *Homo erectus*, Neanderthals and *Homo sapiens*). At all of these sites, archaeologists face a difficult task: they have to assess whether hominins were actually involved in the accumulation and modification of the elephant remains. To support hominin involvement, zooarchaeologists examine the elephant bones for cut marks, which indicate butchering practices and the removal of meat, as well as percussion marks, which point to the breaking of bones for marrow extraction or tool fashioning. Lithic artifacts provide another line of evidence, as they sometimes preserve micro-wear traces and residues that may suggest the use of tools for meat processing. However, these laboratory investigations have their own methodological problems and must be supplemented by a detailed examination of the geological context of the site. Therefore, palaeontologists and zooarchaeologists study the taphonomy of the finds (e.g., cause of animals' death, bone modifications by carnivores and humans, burial, fossilization) and work together with geoarchaeologists and geologists to investigate site formation processes, while archaeologists examine patterns from the spatial association of lithic tools and faunal remains.

At many sites, human exploitation of elephant carcasses has been argued either on the basis of direct evidence (e.g., cut marks on bones, proboscidean bone artifacts, embedded lithics in proboscidean bones) or indirect evidence (e.g., tight spatial arrangement of lithic and faunal material, fat residue and use-wear on lithic tools) (see for example Goren-Inbar et al., 1994; Potts et al., 1999; Yravedra et al., 2010; Rabinovich et al., 2012; Boschian and Saccà, 2014; Santucci et al., 2016; Wojtal et al., 2019). It has also been proposed that elephant exploitation was more than just a marginal phenomenon, and had particular significance in human lifeways and diet during the Palaeolithic. Elephants were by far the largest terrestrial mammal available to Palaeolithic hominins, and represented a unique food package in terms of the quantity of fat and meat (Ben-Dor et al., 2011; Agam and Barkai, 2018). The methods of obtaining proboscidean meat by early humans are still under discussion. While for the Early Pleistocene a significant scavenging component and more opportunistic behavior is considered for megafauna acquisition (e.g., Espigares et al., 2013; Domínguez-Rodrigo et al., 2014), in later time periods hunting (e.g., with traps, ambush, confrontational) became perhaps the principal method for obtaining calories (e.g., Agam and Barkai, 2018). Research at elephant butchering sites tries to assess whether the animals were hunted or scavenged by humans, and, in the latter case, whether humans had first access to carcasses, prior to large carnivores.

"The Palaeolithic record" section of this volume (Part 1) starts with Espigares et al. (Chapter 2), who open the window to the Early Pleistocene setting of Spain. The rich palaeontological and archaeological record of the Baza Basin documents the presence of giant hyenas and saber-toothed cats along with hominins. The authors put emphasis on the site of Fuente Nueva-3, where hominins and hyenas may have competed for consumption of a mammoth. Konidaris and Tourloukis (Chapter 3) investigate the Proboscidea-*Homo* record in Early–Middle Pleistocene open-air localities of western Eurasia from a palaeontological and archaeological perspective, focusing among others on the role of large carnivores, the technological advances in material culture, the important developments in human cognition and on relevant inferences about human social behavior. The authors suggest that proboscidean exploitation during the Early Pleistocene may have been occasional and sporadic, relying perhaps mostly on scavenging, whereas during the Middle Pleistocene megafauna procurement became more regular including also hunting. Palombo and Cerilli (Chapter 4) review the Pleistocene record of human-elephant interactions in terms of several factors, such as the geographical and climatic region, the vegetation type, the diversity of large mammal fauna, the material culture and the taphonomic evidence, and conclude that during the Lower Palaeolithic human-proboscidean interactions were mainly related to "accidental findings", whereas during the Late Pleistocene the exploitation of proboscidean carcasses was more related to a hunting activity. Wenban-Smith (Chapter 5) presents his research in the Middle Pleistocene Ebbsfleet elephant site in the United Kingdom, addressing the issue of megafaunal exploitation and its importance for the investigation of human adaptations through the Pleistocene. Going beyond this, the author provides perspectives on Neanderthal extinction in northwest Europe during the last ice age, highlighting the potentially crucial role that the mammoth-hunting niche played for both Neanderthals and modern humans. Rosell and Blasco (Chapter 6) compile the zooarchaelogical evidence of elephant-human interactions during the Pleistocene in the Iberian Peninsula, and highlight the importance of this geographic region for the investigation of relationships between proboscideans and hominins. The authors conclude that the exploitation of elephants is based mostly on fortuitous encounters, and is characterized by carcass processing at the procurement place or in some cases by the occasional transport of selected anatomical portions to the habitat location. Demay et al. (Chapter 7) synthesize results from zooarchaeological analyses from several Upper Pleistocene sites from Eastern Europe and highlight the importance of mammoths for human territory settlements. The authors present the different ways mammoth resources were acquired (e.g., hunting or dry bone gathering), and describe their use for food, fuel, building material and portable support for tools and mobiliary art.

In the "A view of the evidence" section of the volume (Part 2), Marinelli et al. (Chapter 8) present results from use-wear analysis conducted on small flakes from the Lower Palaeolithic sites Revadim (Israel) and Fontana Ranuccio (Italy), both yielding several megafaunal remains. The comparison with experimental data indicates specific movements and actions related to butchering, especially for cutting soft material, and the authors suggest that small flakes were particularly efficient in anatomical areas of carcasses that would be more difficult to access with larger tools. Giusti (Chapter 9) highlights the need to move beyond the indirect evidence provided by the spatial association of faunal remains and artifacts. The author emphasizes the importance of applying spatial taphonomy in the study of archaeo-palaeontological assemblages, including proboscidean sites, aiming for more detailed interpretations of past human behaviors. Rocca et al. (Chapter 10) report on their investigations in two Lower Palaeolithic localities of Italy, Cimitero di Atella and Ficoncella, and point to the cultural and behavioral variability during the early Middle Pleistocene in Italy, including a great diversity of tools and reduction sequences. Surovell et al. (Chapter 11) report on the La Prele Mammoth Site, a Clovis mammoth site in Wyoming, and demonstrate that humans not only killed and butchered a mammoth, but they also set up a nearby campsite preserving multiple hearth-centered activity areas. La Prele provides a glimpse into the way Clovis foragers solved the logistical challenges of megafauna hunting and efficiently processed a proboscidean kill.

ELEPHANTS IN PAST HUMAN NUTRITION

Human nutrition during Palaeolithic times was based on calories obtained from animal meat and fat, in addition to plant-based foods (e.g., Barkai and Gopher, 2013; Hardy et al., 2015). The importance of fat in the diet cannot be overestimated, as lean protein without fat, as might be available in the carcasses of emaciated prey animals during lean seasons, loses its nutritional value and can even lead to protein poisoning (Speth, 2010). Proboscideans, with their large size and fat content, might therefore have played a crucial role in Palaeolithic subsistence. Many Palaeolithic sites have extensive evidence for large mammal consumption and it has been argued repeatedly that big game hunting was a principal procurement strategy for humans to meet their necessary caloric and nutritional demands (Bunn and Gurtov, 2014; Domínguez-Rodrigo et al., 2014). Moreover, stable isotope analyses evidence the high amount of mammoth meat consumption by Neanderthals and early modern humans (Bocherens et al., 2015; Metcalfe, 2017). Finally, recent research on the fat composition of juvenile frozen mammoths shows a rare nutritional value of the fat itself with a high concentration of polyunsaturated fatty acids, which are known to build up cell membranes and have a different profile according to milk intake (Guil-Guerrero et al., 2014). Correlating this with the large amount of juvenile elephant bones found at various sites and the fact that the fat of young animals is known as better tasting (along with the high vulnerability of juveniles and the lighter weight of their body parts facilitating their transport to human home bases), brings forth the question of specific targeting of juvenile individuals by early humans (e.g., Fladerer, 2003; Blasco and Fernández Peris, 2012; Germonpré et al., 2012; Nikolskiy and Pitulko, 2013).

In the section "Elephants in past human nutrition" of this volume (Part 3), Ben-Dor and Barkai (Chapter 12), analyze data from ethnographic sources and draw our attention to the fact that proboscideans' contribution to human subsistence during the Palaeolithic is underestimated in the traditional zooarchaeological analysis of bone assemblages. The authors make the point, for example, that acquisition of large prey was more energetically efficient and less technically complex than the acquisition of small prey animals. Bocherens and Drucker (Chapter 13) provide isotopic insights on ecological interactions between humans and woolly mammoths during the Middle and Upper Palaeolithic in western, central and eastern Europe. Their results indicate a high amount of mammoth meat consumption by late Neanderthals and early modern humans. The authors also address the question of the predatory pressure exerted by modern humans on the woolly mammoth well before its extinction. Blasco and Fernández Peris (Chapter 14) summarize zooarchaeological data from the Middle Pleistocene site of Bolomor Cave in Spain, where the faunal assemblage ranges from very small-sized animals (lagomorphs, birds and tortoises) to very large-sized herbivores (elephants, hippopotamuses and rhinoceroses). The hominin exploitation of such a wide range of animals indicates a generalist behavior based on a broad spectrum diet, and highlights the diversity in the lifestyles of the human communities of the European Middle Pleistocene. Germonpre et al. (Chapter 15) examine the season of death of juvenile mammoths at several Middle and Upper Palaeolithic sites from Central and Eastern Europe. The authors conclude that the hunting of mammoth calves took place during all seasons and was not limited to the cold part of the year, and that their carcasses, heads or other body parts were transported to human settlements. Fisher (Chapter 16) based on ethnographic parallels and his experimental studies, discusses under-water storage of Late Pleistocene proboscidean carcasses for securing, concealing, and returning to utilize nutritionally significant carcass parts. By pointing out the role of under-water storage of human subsistence, the author sheds light on an important aspect of human subsistence strategies centering on megafauna.

ETHNOGRAPHY – HUMAN-ELEPHANT INTERACTIONS IN RECENT AFRICA

Anthropological and ethnographic research documents the interactions of extant hunter-gatherers with elephants, mostly in parts of central Africa and India (e.g., Terashima, 1986; Joiris, 1993;

Naveh and Bird-David, 2014). Several contemporary hunter-gatherer groups in the Central African Republic, Republic of the Congo and Cameroon, such as the BaYaka, Baka, Aka, Efe and Mbuti, are still using traditional weaponry such as spears in elephant hunting, and still process and consume elephant carcasses (e.g., Lewis, 2015). This window of opportunity for research into this behavior is being rapidly shut down, however, as guns are being supplied to hunter-gatherer groups by local farmers in exchange for the tusks of the hunted elephants. Nevertheless, during the past decades and particularly in recent years, anthropologists were able to document and study the elephant hunting practices of these groups, the post-hunting processing of elephant carcasses, as well as the role of elephant meat and fat in the diet of hunter-gatherers. Such valuable information could and should shed new light on the silent archaeological record, while the rich and extensive Palaeolithic evidence for similar interactions with elephants throughout hundreds of thousands of years enables a time-perspective into the nature of human-elephant relationships in the past.

Ethnographic and actualistic studies of present-day patterns and processes constitute an invaluable source of information as analogues that help to interpret the archaeological record. For instance, modern elephant butchery experiments have demonstrated that it is possible to deflesh carcasses without leaving visible cut marks or other markings on elephant bones. Ethnographic research also informs us about non-dietary utilization of elephant remains with practices that are almost "invisible" in the archaeological record. There is ample evidence that, during the Palaeolithic, elephant bones were often used as raw material for tool production. Proboscidean bones were also used as fuel and as material for constructing dwelling structures and windbreaks. However, it is the current anthropological research on hunter-gatherers that can inform us on practices with a weaker (if any) archaeological signal: for instance, the use of dried hides for clothing; elephant foot-pads used as bowls; or soft tissues, such as tendons, used for making bindings.

In the section "Ethnography – Human-elephant interactions in recent Africa" of this volume (Part 4), Lewis (Chapter 17) focuses on the fact that elephants pose a real danger to BaYaka hunter-gatherers of Congo, and that approaching and killing an elephant with a spear is an extremely difficult and risky task. The author describes traditional techniques for hunting and killing elephants, and their accompanying rituals, focusing on their significance for the BaYaka cultural identity, economics and politics. Ichikawa (Chapter 18) describes elephant hunting methods with spears, hunting party and success rate, the distribution of meat, and the festive nature of meat consumption by the Mbuti hunter-gatherers in the Ituri forest of the eastern Congo Basin. The author discusses the low success rate of elephant hunting, but also the huge quantity of meat supply in a successful hunt, as well as the accompanying ritual performances and festive meat consumption. Finally, Yasuoka (Chapter 19) reports on his investigations on the Baka Pygmies in Central Africa, focusing on the complex procedure that accompanies elephant hunting, and the structure of the Baka Pygmies' egalitarian society. The author explores aspects of elephant meat sharing and provides ontological clues of elephant hunting, most notably the taboo that forbids the hunter who killed an elephant from eating the meat.

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1. AN EMBARRASSMENT OF RICHES: THE ONTOLOGICAL ASPECT OF MEAT AND FAT HARVESTING AMONG SUBARCTIC HUNTERS

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ABSTRACT

If we hypothesize that Pleistocene hunters understood animals to be self-aware other-than-human persons, as contemporary hunter-gatherers tend to do, what evidence of this kind of relationship might appear the material record? While the "turn to ontology" within anthropology has mainly used, as evidence, a group's consciously held ideas, part of a people's assumptions about reality are unconscious, and revealed only in behavior. The chapter examines the potential of the ethnographic analogy, using the example of some contemporary North American subarctic hunters. In particular, I look at how their ontological assumptions are reflected in their material culture, such as in their treatment of animal bones, their pictographs and other decorations, their veneration of particular rocks, and the significance they attach to certain colors.

1.1 INTRODUCTION

Can contemporary Canadian subarctic hunters give us clues to the kind of relations that Pleistocene hunters may have had with the large animals they hunted, such as elephants? While modern northern hunters do not have access to game with as much meat and fat as these megafauna, they have legends about monster versions of present-day game animals, and some of their ancestors hunted mastodons and other very large game. Even today, large quantities of meat and fat periodically arrive in their camps, which trigger activities like butchering, storing, cooking, feasting and sharing. These hunters have detailed knowledge, embodied skills and empirical experience of the habits of each of the animals they harvest, on the basis of which they employ optimal foraging strategies (Winterhalder, 1983). However, as part of this process of food procurement hunters engage seamlessly in

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animist practices, including communicating with and making presentations to game animals. The logic behind these practices is more challenging for anthropology, as they conjure up a world with unfamiliar forms of determinism.

Hunter-gatherers, like all humans, work at understanding, predicting and controlling those factors that affect their own wellbeing, especially, in this case, their hunting success. To this end they make use of their detailed knowledge and experience of each animal species' habits. Even so, encounters with animals in the wild involve a degree of unpredictability and mystery. It is probable that, like their modern counterparts, hunters of the deep past had techniques to penetrate this mystery.

There are obvious difficulties with projecting back the practices of recent hunter-gatherer onto earlier peoples. In the first place, there is no single hunter-gatherer way of life. Yet it can be useful to examine some of the general principles underlying hunter-gatherer practices in general. One such feature that seems to be common, at least among contemporary and historic hunter-gatherers, is animism. This is the perception that certain animals, and even certain plants, material objects and meteorological phenomena, have person-like qualities, such as agency and memory. They also share with humans a moral sensibility, such as the principle of reciprocity.

In their attempt to illuminate the logic underlying animist ideas and practices, many authors have framed the issue in terms of diverse ontologies. That is, attention is being drawn to how different human groups apparently experience and make sense of reality in distinctive ways. Various kinds of ethnographic and archaeological material are being used to demonstrate the alterity of a group's ontology, drawing, as evidence, on stories, myths, ceremonies, cosmologies, and artistic expressions (Hallowell, 1964; Ingold, 2000; Viveiros de Castro, 2012). Describing an ontology on the basis of these kinds of sources suggest the attribution of some degree of self-awareness by peoples of their own ontologies. Blaser (2013: p. 552), for example, suggests that the stories a people tell are close to a synonym for their ontology. However, it is important to also acknowledge the unconscious aspect of ontology. Many of the assumptions a people hold about the nature of reality are largely "taken for granted". As Evans-Prichard (1965: p. 6) noted "much of the thought of primitive peoples is difficult, sometimes almost impossible, for us to understand, in that we cannot follow their lines of reasoning because the underlying assumptions on which they are based, while taken for granted by them, are totally alien to us".

Moreover, in their day-to-day lives most speakers are unaware of how the conceptual logic of the own language they use shapes how they see the world. Folk taxonomy studies indicates the existence of cognitive categories that are implicit, and thus hardly conscious to those that hold them (Berlin et al., 1968). According to Viveiros de Castro (2012: p. 65) "[…] People do not act out […] cosmologies […]. The peoples of the world live through practice, in practice, and for practice".

I am not arguing that some ontological assumptions about reality are in principle unconscious. However, outside the context in which two groups with diverse ontologies find themselves in conflict over what is real (Blaser, 2014), most people do not spend much time contemplating their ontological assumptions; instead they are simply unquestioningly taken as given. There are other reasons why we must look beyond what ethnographers can infer from local knowledge. Some shamanistic knowledge is purposefully kept secret. However, we can infer aspects of a group's ontology that are not spoken about by paying attention to their practices. And if it is the case that actions speak louder than words, then it is archaeology which pays attention to this louder voice, finding the evidence of the practices of archaic peoples, even without direct evidence of the group's explicit ideas about their own ontological assumptions.

In this chapter, I will first outline some cautions and opportunities in the use of ethnographic analogy. I will then outline the way of life, practices and philosophical ideas of two culturally-related northern Canadian Algonquian hunter-gatherer groups, the Iyuu and the Innu of the Quebec-Labrador peninsula (Fig. 1.1). I will look in particular at their techniques and skills for acquiring and handling large quantities of meat and fat, as well as how their distinct ontological perceptions influence these practices. These two groups live in slightly different environments, and have a somewhat different range of game animals, as a result of which they have different forms of land tenure. Yet they have very similar ontological attitudes towards external reality, particularly towards the animals and the environmental phenomena they encounter every day. I examine their animist practices in relation to certain material substances like fat, stone, bone and animal hide. I then point to material evidence for these practices as these relate to their animist ontology. Finally, I draw some conclusions about how such ethnographic observations of modern and recent hunter-gatherers may inform the interpretation of the traces left by early humans.

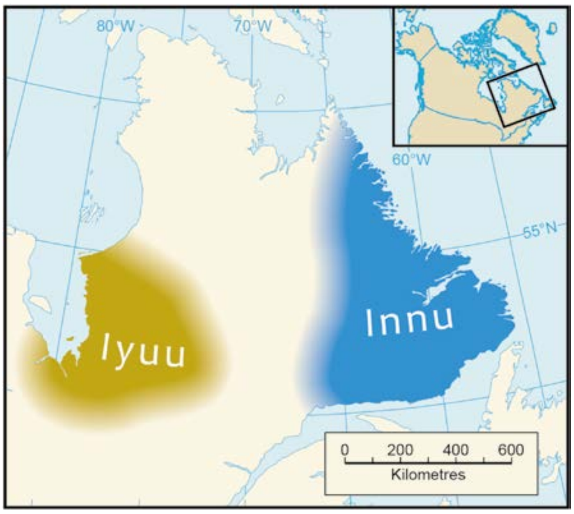

Figure 1.1: Approximate locations of the Iyuu and the Innu of Quebec-Labrador. Courtesy of David Mercer, Map Room, Queen Elizabeth Library, Memorial University.

1.2 THE ETHNOGRAPHIC ANALOGY

Some have questioned whether the concept of hunter-gatherers is in any way meaningful as a social category, let alone as a model for the analysis of cases from the deep past, given the wide diversity among peoples who depend on harvesting wild animals and plants (e.g., Johnson, 2014; Finlayson and Warren, 2017). This literature draws attention to such features as diverse settlement patterns and differences in social organization among different hunter-gatherers groups. While contemporary examples are generally found in environments unsuited to agriculture, these cover the range all the way from tropical to arctic. In contrast to Pleistocene hunter-gatherers most modern hunter-gatherers have some economic relations with their agricultural or pastoralist neighbors, or with market-oriented systems (Bird-David, 1992). For some groups gathering wild plants is as important to them nutritionally as is hunting, while others depend for food almost exclusively on hunting and fishing. While kinship is generally a central social organizing principle among hunter-gatherers, some have matrilineal, some patrilineal and some bilateral systems (Arcand, 1988).

Despite this variety, there are also certain commonalities. Most hunter-gatherer groups are organized around a self-provisioning economy, that is, they directly provide for most of their own food and shelter, as well as for luxuries, ritual observances and leisure, and are thus only secondarily oriented towards trade or wage labor. While both the Iyuu and Innu, cases I will refer to in more detail below, have engaged with the fur trade for many years, and others sometimes engage in wage work (Tanner, 1968), I have argued elsewhere that they still maintained a self-provisioning economic orientation (Tanner, 2014: pp. 124–129). A group with a self-provisioning economic orientation is primarily motivated to produce, whether for their own use, for trade, or for wages, in order to satisfy the known needs of their own residential family group. Harvesting or other forms of production generally end when they had enough for present and foreseeable future needs, with participants opting instead for activities like ceremonial or leisure.

The practice of sharing within local groups, rather than barter or trade, is the most common form of distribution among hunter-gatherers (Bird-David, 1992; Ichikawa, this volume; Lewis, this volume; Yasuoka, this volume), as, it has been argued, was the case with particular Pleistocene hunters (Barkai, 2019). With some famous exceptions like the North American sedentary Northwest Coast fishers, most hunter-gatherers are equalitarian, at least in terms of individual access to material benefits (McCall and Wilderquist, 2015). Hunter-gatherers tend to have forms of social organization that allow for flexibility in residential group size. The family is the fundamental unit of both procurement and consumption, with a gender and age-based division of labor. Through their butchering practices, hunters have a sophisticated understanding of the physiology of each game species. Hunters tend to have uses for every part of the animals they harvest. In such groups fat is particularly important nutritionally, due to their limited access to carbohydrates, and their very high protein diet.

The above features are not all unique to hunter-gatherers, some being shared with pastoralists and simple horticulturalists. But in general hunter-gatherers have a special kind of holistic and intimate relationship with their environments, by contrast with the more selective focus that is found with other forms of production. Most of them regularly cover large areas of land, usually on foot, constantly updating their knowledge while also on the lookout for new harvesting opportunities (Tanner, in press). While hunters may have played a role in the extinction of some megafauna, they have generally had a much smaller impact on their environment than has been the case with agricultural or industrial societies. As a result, some hunter-gatherers have been able to maintain over long time periods a sustainable relationship to the lands and waters that they occupy. And, most importantly, all hunter-gatherers have the regular, yet always mysterious, experience of close encounters with wild animals. These general features almost certainly also existed among hunter-gatherers of the deep past.

1.3 ANIMIST ONTOLOGY

Many if not all hunter-gatherers have an animist perception of the environment, and of animals in particular (Ingold, 1996, 2000; Bird-David, 1999). One implication of this is that such groups perceive no fundamental nature-culture opposition, and thus no radical separation between the worlds of humans and that of the animals, plants and environmental phenomena. Humans and game animals belong to the same social world, and as such are mutually bound by some of the same moral principles. Game animals, or the whole environment, is often characterized as having generally friendly, sharing relationship with hunters.

There has been much recent interest in hunter-gatherers' ontology—that is, in their basic assumptions and perceptions as to the nature of external reality and of existence (e.g., Viveiros de Castro, 1998, 2004; Blaser, 2013, 2014; Descola, 2013). This approach is also being used by some archaeologists (e.g., Hill, 2011; Comba, 2013; Hussain and Floss, 2015). While this topic is approached by different scholars from different starting places, "all share a focus on the question of whether agents perceive and experience the same reality in different ways or whether they experience and exist in different realities" (Oman-Reagan, 2015).

The issue of multiple ontologies can be approached from the solipsist observation that humans can never completely know the external world. With our fixed set of sensory organs we cannot fully perceive and engage with all aspects of reality at any one time. Human perception and understanding of reality is thus a social construct. While all people have the same set of sensory organs, not all groups arrive at the same understanding as to the nature of the external world.

For one thing, different human groups arrive at different assumptions as to the basic primary colors (Berlin and Kay, 1969; Saunders, 1992). For example, the language of the Iyuu and Innu, hunter-gatherers who will be discussed in detail below, has a single term that covers the part of the spectrum that, for English speakers, includes both green and blue (Tanner, 2014: p. 217). Moreover, different peoples attach different interpretations to colors (e.g., Dixon, 1899; Zawadzka, 2011), an issue that has also been pursued in archaeology (e.g., Jones and MacGregor, 2002). Some peoples classify phenomena in their external world, such as all living things, according to different principles than do others (Berlin et al., 1973). Attempts to understand such different ways of thinking has a long history in anthropology, much of it focussed on language. The issue was addressed by the Whorf-Sapir hypothesis (Whorf, 1956), which proposes that the diverse ways different languages are structured influence a speaker's world view. However, in addition to language, we can also gain some access to assumptions people make about the nature of external reality by observing their non-linguistic forms of behavior, including practices taking place in the standardized context of rituals and ceremonies.

Given that not all humans make the same ontological assumptions about external reality, Oman-Reagan (2015) has suggested that the best that a Western anthropologist can do is to document the way by which others see the world, especially in ways that do not conform to their own ontological assumptions about reality. However, they can only do so from their own perspective.

"[An ethnographer] is eventually forced […] through the process of writing about his experience, observations, and analysis, to refer back to signifiers from his own group. He must do this translation using signs with meaning, signs with iterability, signs that make some sense to his audience" (Oman-Reagan, 2015: p. 4)[1].

How do we escape from this dilemma? Anthropologists might follow the procedure used by the physical sciences to arrive at their understandings of newly discovered phenomena that do not happen fit within their existing models. They change what Kuhn (1962) calls their scientific paradigm, that is, the prevailing "grand theory" of their branch of science, such that they are able to make accommodation for the newly discovered phenomenon. Scholars who are addressing the issue of multiple ontologies need to adopt the perspective of a meta-ontology by which such comparative ontological studies may proceed. I am not suggesting science currently provides such a ready-made meta-ontology. However, for scholars to study multiple ontologies comparatively they need to undertake the difficult task of setting aside the assumptions of their own "native" world view.

The fact that some of the shared ontological assumptions may be normally held unconsciously is not a barrier to their investigation. The unconscious may reveal itself in behavioral practice. There are actually certain advantages to giving priority to human practice over the accounts that a group may give about their own perception of reality. For example, my own preferred ethnographic research method is "participant observation"; before asking questions a researcher pays attention to the practices of the people being studied. In my case, after living with and observing an Iyuu hunting group for some months I had acquired a basic idea of how people normally behave under various specific circumstances, including in the context of ceremonies and rituals. It was only then that I began to inquire as to people's conscious awareness of, and rationale for, these behaviors, particularly for those practices without a self-evident rationale.

In terms of theory, Bourdieu's concept of habitas is intended, among other things, to deal with the role of the unconscious in the production of knowledge, and with the ability in human thought to overcome contradictions (Bourdieu, 1990). I confronted what I experienced as contradictions while living with the Iyuu/Innu. Even though animals give themselves to worthy hunters, at the same time these hunters regularly observe that, when approached, many animals will try to flee. Hunters may also acknowledge that some of their encounters with animals can involve a battle of whits, sometimes ending with the successful hunter obtaining the game animal by means of trickery. According to the Iyuu/Innu animist ontology such outward manifestations are misleading, hiding

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[1] On this question, see also Willeslev (2016).

what is really going on, and particularly what the animal really wants.

As noted, modern hunter-gatherers are generally animists. This contrasts with "theism", according to which the external world is perceived as having been created and managed by one or more powerful entities or gods. But there is no single form of animism. Evidence of artifacts made by early hunters depicting game animals, like the cave drawings, carvings or amulets, have been interpreted by some scholars that their makers related to these animals as fellow persons (Hill, 2011; Betts et al., 2015; Jones, 2017; Qu, 2017; Demay et al., this volume). How might such a person-to-person relationship to the animals be reflected in other aspects of the archaeological record, such as how the animal corpses were treated? The material conditions of hunting and the ontological perceptions and motivations of hunters bear equally on this question. In what follows I will focus on how two related groups of subarctic hunter-gathers balance their food needs with their ontological perceptions of the needs of their prey.

1.4 SUBARCTIC HUNTERS

For the modern and historic northern North American small-group, nomadic hunter-gatherers, each kill was in essence a gift from the animal, an other-than-human person who feels sympathy towards needy humans. Hunters interacted with game animals so as to remain on good terms, treating them with respect, and paying attention to any communication from them. I noticed that hunting group members were careful to monitor and share their dreams, and elders sang and drummed to the animals in preparation for a hunt. While hunters worked to maintain a relationship of friendship and mutual respect with game animals, they were also aware of other less friendly entities—creatures that have evil power and an antagonistic relationship with humans (for the Iyuu/Innu classification of animals with evil powers, see Bouchard and Mailhot, 1973: pp. 44–55).

Hallowell, who initiated the study of ontology within anthropology on the basis of his research with the Anishinabe (Ojibway), a close relative of the Iyuu/Innu, avoided Western concepts like "spirits", coining instead the phrase "other-than-human persons" (Hallowell, 1964). In this article, I use the term ahchaakw, which in the Iyuu language refers to the various normally invisible but powerful entities, some of which are associated with game animals with whom the Innu communicate. One way that many Iyuu know about these entities is from having attended a "shaking tent" (*kusaapahchikan*) ceremony, a public event in which a shaman enters a small barrel-shaped open-topped tent, which then begins to shake violently after an ahchaakw enters (Feit, 1994, 1997)[2]. By contrast to Siberian shamans, who leave their bodies to travel to the world of the "other-than-human" persons, Iyuu/Innu shamans bring the ahchaakw to them. There is a host *ahchaakw* in the *kusaapahchikan* performance, called mistapeu, who introduces and translates for the other *ahchaakw* who enter the tent. There is an *ahchaakw* for each of the four cardinal winds, one for each the animal masters (referred to below), as well as for certain unusual animals, such the one whose name means "under-water panther", and another whose name means "flying dog". By means of drumming and singing, undertaking divination rituals, or paying attention to their dreams, any adult can communicate with animals and their associated *ahchaakw*, but only a shaman (*miteuu*) has the power to be able to perform the shaking tent. This ceremony is a public demonstration and affirmation of some of the fundamental entities of Iyuu/Innu ontology.

While detailed practical knowledge and skills are essential for hunting success, when an animal was killed the hunters themselves did not credit success to their own skill, but instead to the positive state of the relationship between the hunter

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[2] There is an online video source in which Feit is interviewed about a filmed shaking tent performance that he witnessed (Maamuitau n.d. Shaking Tent; https://gem.cbc.ca/media/maamuitaau/season-33/episode-9/38e815a-009e58f54e7; last accessed April 26, 2020).

Figure 1.2: Bear skulls. Photograph by Adrian Tanner.

Figure 1.4: Elevated platform to protect animal bones. Photograph by Adrian Tanner.

Figure 1.3: Display of antlers and beaver skulls. Photograph by Adrian Tanner.

and the species in question. Neither was the killing of wild animals seen as a matter of luck. Rather, it entailed the hunter being in a situation, both physically and mentally, to receive animal gifts. Like the BaYaka (Lewis, this volume), the Iyuu/Innu attribute hunting success to ritual, although in their case the rituals are presided over by elders, most of whom are men, rather than by women. Moreover, elders to whom such power is attributed may find themselves suspected of using it to harm others (cf. Ichikawa, this volume).

Showing respect to game animals includes treating the corpse as a sacred substance that should never be wasted. As with the BaYaka (Lewis, this volume), among the Iyuu/Innu it is improper to laugh at an animal carcass. Hunters generally avoided killing anything for which they did not have the need. Most meat and fat that was not consumed at a communal feast was shared and preserved by each family group for its future use. Some hunters engage in an "Eat-all" feast, held after a hunting group has acquired large amounts of food (Brightman, 1993: pp. 213–217). At these feasts, any nearby hunting groups were invited, under the injunction that the meal could only end when all the food had been eaten. This feast acknowledged, symbolically, that humans are collectively under the obligation to consume whatever gifts the animals provide.

Dealing with large quantities of meat poses practical and intellectual challenges. Like human gift-givers, the animals want hunters to show their appreciation. While individual animals have agency, whole species, or groups of species, have a named "master" ahchaakw who can exercise control over their animals. To neglect the rules for how an animal should be treated can result in the "master" *ahchaakw* of a species withdrawing these animals, such that for a period an offending hunter, or in the most serious cases all hunters, may be unable to kill any of the species in question. Bones, antlers and whatever else is not used should be preserved, and not treated as garbage for scavengers to consume. The skulls were generally hung in the trees around the camp (Figs. 1.2, 1.3), or on a specially erected pole, while the other bones of land animals were put on an elevated platform (Fig. 1.4), and those of the fish and other water animals, as well as some land animals, were deposited under water. Any unusual part of an animal, such a bone found to have an unusual lump, was treated as having divinatory significance. Certain animal parts, such as the scapular bone, are used in divinatory rituals, while others are used in games. Some hunters kept a decorated animal part, such as the hide and fur from the chins of bears, or the dried heads of geese.

A successful hunt was followed by a time of celebration, but it also meant a lot of work for ev-

Figure 1.5: Cache platform for food storage. Photograph by Adrian Tanner.

ery member of the hunting group, especially for the women, to transport the meat to the camp, to butcher the carcasses, to organize and prepare a communal feast, to distribute food gifts outside the producing group, and to store the remaining meat and fat. In winter, storage merely involved putting the partially butchered carcass outside to freeze, on a cache platform (Fig. 1.5), inside a wooden enclosure or under a pile of rocks (Rankin, 2008).

In many ways the winter was, for the Iyuu/ Innu, the time of plenty. Walking on snowshoes, hunters had unlimited access to all part of their hunting lands and frozen waters, while fresh animal tracks were easily discernible in the snow, and meat and fat could be stored with ease by freezing. The fat was rendered and stored in containers, and meat could also be smoked or sun-dried and powdered (Fig. 1.6). Today the large harvests of geese and fish are preserved in freezers in the settlement, but in the past they were smoked and dried.

Figure 1.6: Drying and powdering moose meat. Photograph by Adrian Tanner.

1.5 HUNTING AMONG THE IYUU

Two closely related hunting peoples who inhabit different parts of the Quebec-Labrador Peninsula are the Iyuu (aka East Cree), who live on the western side of the peninsula, and the Labrador Innu (aka Montagnais-Naskapi) living on the eastern side. Although both groups are now settled in permanent villages, until recently they passed the eight or nine month winter season in scattered nomadic camps inhabited by groups of two or more families. The following observation are from fifty years ago, which is why I use the past tense, even though many of these practices continue to be followed today.

In the eastern Quebec-Labrador region where the Iyuu reside (Tanner, 2014), their food animals happen to be relatively sedentary, particularly moose and black bear. Although not big game, the highly sedentary beaver was another dependable source of food. Fishing was conducted year-round at known productive lakes and rivers, in winter through the ice. Flocks of migratory geese arrived each spring and fall at predictable locations, providing large and dependable quantities of meat and fat. Woodland caribou were not sedentary, but were killed opportunistically. Women tended to harvest close to the camp, bringing in ptarmigan, grouse, rabbits (arctic hare), large quantities of fire wood, boughs for flooring, as well as lake fish, and berries in summer. The Iyuu and Innu both had a “broad spectrum diet” (Blasco and Fernández Peris, this volume). The associations proposed by Ben-Dor and Barkei (this volume) of women with small game; men to large game, as well there being more ritual associated with large game, is generally the case with the Iyuu/Innu, with some important exceptions.

Given these ecological conditions, the Iyuu have developed a system whereby each hunting group returned annually to a particular delimited territory, within which they moved camp every few weeks. The Iyuu do not think of this arrangement as land ‘ownership’ in the Western, real estate sense; some hunters told me “the animals own the land”. Other Iyuu hunters were permitted to harvest while travelling through one of these territories, but they needed the group’s permission to reside there over the winter season. By means of this land tenure system hunters were able to have a sustained relationship with the animals, including leaving some animals behind to maintain the population for subsequent years. These territories also ensured that resources were shared evenly.

Figure 1.7: Preliminary butchering at a kill site. Photograph by Adrian Tanner.

Figure 1.8: Some of the 'Tokens' that announce a kill. Photograph by Adrian Tanner.

They allowed hunters to constantly update their knowledge of the local, potentially dynamic, environment, particularly following forest fires. While these practices have certain parallels with Western ideas around "conservation", Scott (2006: p. 63) notes that Iyuu knowledge puts the primary emphasis on "relational sustainability", and not on "system management", which is the preferred approach of modern wildlife managers.

While small game, fish or fur-bearers were harvested on most days, periodically, when conditions were right, a collective hunt was undertaken for larger animals—moose, caribou or bear. During these hunts there was a group leader, but all participants respected each others' autonomy. Each hunter possessed all the wherewithall to be able to survive comfortably—a gun, an axe, a fire lighter, etc.— should by any chance they become separated for extended periods. These hunts usually produced one or two animals. Moose, on average, provide 150 kg of meat and fat, caribou 48 kg and bear 60 kg.

As in the case of the Baka (Ichikawa, this volume), the Iyuu employ non-verbal means to announce their success. Moose and caribou were usually skinned, gutted and buried in the snow at the kill site (Fig. 1.7), and any traces of blood removed from the snow to avoid offending the animals, after which the hunter returned to camp and announced the kill to the rest of the group, by bringing back "tokens" (Fig. 1.8). These tokens may have included the legs, the heart, part of the

Figure 1.9: Ritual display after a successful hunt. Photograph by Adrian Tanner.

lower intestines, fat from around the kidneys, and fetuses from any pregnant females. The following day the rest of the animal was transported to camp by all adults, although sometimes a group would choose to move its camp to the kill site. In the month of April hunters harvested particularly large quantities of game meat—in the case of one group I lived with a total of six moose and one caribou were killed over a few weeks, producing over a thousand kg of edible meat and fat. At the time the group knew the locations of more moose they could have killed, but decided to finish hunting, as they judged they had sufficient. This large harvest was planned because the breakup period was about to commence, a time of year when movement becomes difficult due to the melting of snow and ice. Some of that meat was consumed over the several weeks of breakup, while the rest was dried and powdered, to be consumed over the following summer, or given as gifts.

This large harvest was marked by the ritualized display of the corpses inside the hunting groups leader's tent (Fig. 1.9). For about two hours members of the hunting group sat around admiring the meat, after which it was divided up between the two families. On other occasions, a whole animal, such as the first caribou killed in the season, was brought inside the dwelling, for the whole group to admire, before being butchered. One of the rules for respecting game animals is for a hunter to be humble, to not brag about any hunting success, as this gives offence to the animals [cf. Ichikawa (this volume) on the need of Baka hunters to be humble]. Thus, these meat displays were a muted celebration by the collectivity, without drawing particular attention to one successful hunter.

The Iyuu consider the bear to be an especially important animal, such that its killing sets off much ceremony. The slain animals should be brought to the camp immediately and butchered there, followed by a special feast that involved many rules and taboos. Among these taboos is the designation as certain portions being designated "man's food", also mentioned by Lewis (this volume) for the BaYaka. As noted by Scott (2006: p. 64), for the Iyuu "the bear is the paramount symbol of the imperative for respect". As noted below, bear grease was treated as a sacred substance.

1.6 HUNTING WITH THE INNU

The Labrador Innu on the eastern side of the peninsula had a similar way of life to the Iyuu, although with a particular dependence on caribou. Not only did this animal traditionally supply large part of their material needs, but it was also special to them in terms of the efforts hunters took to remain on good terms with the species. The northern Innu region is a taiga environment over which the large George River herd of barren ground caribou roams on its seasonal migration (Henriksen, 1973). During the 19th and early 20th centuries, one local group of Innu adopted a regime of year-round occupancy in the interior, depending largely on this herd. They conducted their main harvest of caribou in late summer, when the herd's migration path crossed the George River. However, first in 1915, and again recently, the herd's population declined drastically, making these large caribou harvests impossible. The Innu attribute this shortage to the caribou "master", known either as *Papahasiku* or *Kanipinikassikueu*, taking offence at some wrong-doing of theirs, and withdrawing the caribou beneath a sacred mountain to the north. I will therefore quote an eyewitness account by the explorer, William Brooks Cabot. He writes that in 1906 he encountered a camp of eight men and boys, with wives and children, who "had speared no less than twelve or fifteen hundred deer in a few weeks. From three to five hundred carcasses, skinned and washed out, were hauled up on the gravel beach, drying hard and black in the sun and the cool September wind. There were no flies about them and no smell. […] The head was always gone—the hunter himself must eat it or forfeit his fortune in the chase; the meat belongs to the group in common. […] A little fire was made outdoors […] and a large kettle went on, filled well up with crushed marrow bones. […] After it had boiled enough Ostinitsu [the group's leader] skimmed the grease […] off the top […]. A long windrow of horns, besides the separate pile of very large ones, were close by […]. It is a matter of necessity that the horns are piled together; if they are left about it is understood that the deer will scatter when they come through the country, and be hard to get" (Cabot, 1912: pp. 239–242).

Cabot returned to the same area in 1910. He found that "The long windrow […] had disappeared—of course into the lake. This disposal counts as an offering to the powers that rule the chase; without such observances the surviving deer will be offended and avoid the hunters." (Cabot, 1912: p. 265).

The rendered fat and dried and powdered meat was eaten over the following months. Caribou were also hunted at other times, when the herd was more scattered. These Innu also hunted black bear, porcupine, beaver, and lynx. Like the Iyuu, women and elders harvested close to the camp for lake fish and small game. Caribou supplied most of their needs, and since hunting this migratory species conflicted with the more sedentary requirements of trapping, the Innu had relatively little involvement with the fur trade. A successful caribou hunt called for as particular fat-oriented feast, the makushan, a topic to which I will return.

Also on the east side of the peninsula, but further south, in the more forested areas, Innu hunters had access to a somewhat larger variety of game and fur-bearers, but were also primarily dependent on caribou. In their case it was the woodland variety, caribou that live in small herds with limited ranges, but which are also continually on the move (Tanner, V., 1944; Armitage, 1990; Mailhot, 1997). Given that both these Labrador Innu groups were primarily focused on hunting nomadic caribou, they did not have delimited family hunting territories, despite government efforts to introduce them to the region. Hunters gathered seasonally in larger residential groups, when and where there were adequate quantities of fish and other localized game to support many people, and they scattered in individual hunting groups at other times. In summer, some Innu traveled to the coast to fish migratory species and to hunt water fowl at favored locations like river mouths.

1.7 SHARING

Both the Iyuu and Innu regularly shared meat and fat, either at a communal feast or as gifts. If two men were hunting together and one of them killed a moose or a caribou, the whole animal was immediately given to the second hunter. However, this only meant the recipient could keep the hide, since upon returning to camp all the meat was divided among the other families in the group. As with the Mbuti (Ichikawa, this volume), a hunter's ownership of a game animal is only nominal. Among the modern Innu who are settled in villages, most caribou hunting is conducted by groups using snowmobiles or chartered aircraft. Yet upon their return to the village the traditional sharing rules and practices continue to be followed. Sharing takes place both at a feast, and as each hunter gives part of the meat and fat of the animals he has killed to his network of relatives and friends (Castro, 2016).

Sharing meat and fat between families in a winter hunting group occurred without much formality. A hunting group's store of food was not treated as common property open to all; rather each individual family maintained its own larder. I did not observe any demand sharing; rather, each family remained aware of the state of the larders of the other families, and at appropriate times gifts of uncooked food were sent, ahead of any expression of need by the recipients. As in the case of the Baka (Ichikawa, this volume), "sharing is conducted such as to avoid engendering feelings of indebtedness towards the successful hunter". Also as with the Baka, this includes the practice of using children to carry gifts of food to other families. The arrival of visitors was always marked with commensality and other forms of food sharing. At the summer gatherings bush food was bartered outside the extended family. During the pre-contact period when there were extensive Indigenous trade networks it is possible that meat and fat may have been traded. The practice of sharing with strangers was an established tradition—gifts of meat were given to some of the first European explorers who encounter Innu at the coast (Bakker and Martijn, 1991).

Food was also shared with the ahchaakw. Both the Iyuu and the Innu shared morsels of animal meat or fat in the fire with the during meals, particularly at feasts (cf. Ichikawa, this volume). Tobacco offerings were made, for example by placing some in the nasal cavity of a bear's skull that had previously been hung on a tree. Tobacco was also put in the water before shooting a rapid or venturing across a large lake by canoe, a gift for the ahchaakw to ensure a safe passage.

1.8 ANIMAL FAT AND FEASTING

Fat was of special importance to hunters, both now and in the past, given the high protein diet with little access to carbohydrates (cf. Ben-Dor et al., 2011). As is the case with many hunter-gatherers, including the Mbuti (Ichikawa, this volume), fat is the most highly prized part of an animal. As with Inuit words for snow, there is no single Iyuu/Innu term for fat, but terms for each kind from particular parts of an animal. Both moose nose and beaver tail are mainly composed of a fatty substance, somewhat like butter, and are among the most highly prized foods. Sections of the intestine of the moose that have a thick layer of fat are turned inside out, resulting in a fat-stuffed sausage that is smoked before being cooked. Most of the tokens that hunters bring back to camp to announce a large animal kill are especially rich in fat, such as the long bones, and fat from the animal's intestines. As noted, bear fat has a sacred aspect. At the start of the winter hunting season the Iyuu smeared bear fat on their hair, on the door posts of their communal lodge, and on their guns, to ensure success in their hunting during the following season. This relates to their animist ontological understanding that hunters have relationships with the ahchaakw of their guns, doorways and other objects, including, as noted below, with some kinds of stone.

Many northern animals build up fat over the summer and loose much of it over the following winter. One reason beaver is an exceptionally important food animal for the Iyuu/Innu, quite apart from the value of its pelt in trade, is that it maintains its thick layer of fat all winter long. At the other extreme, ptarmigan, grouse and arctic hare have very little fat at any time of the year, such that hunters say a person will starve to death if they try to live exclusively on a diet of these animals.

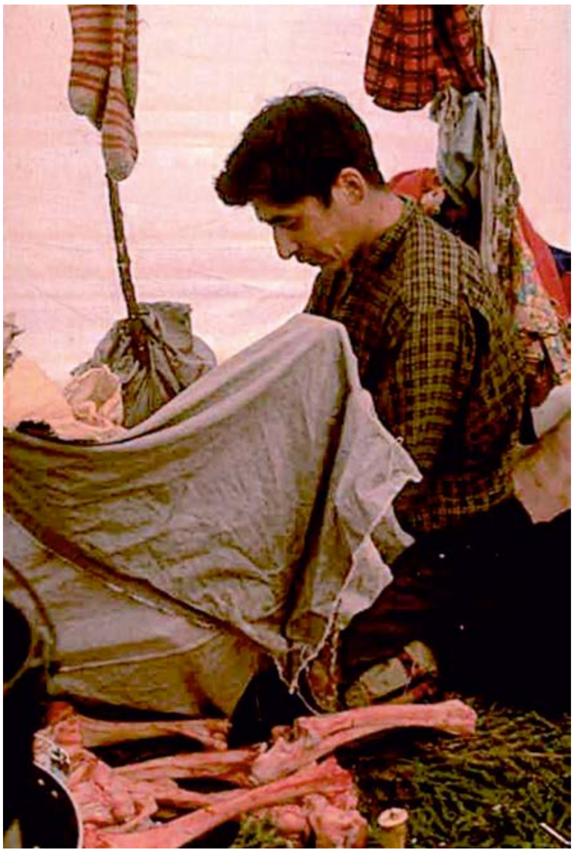

Figure 1.10: Preparing the caribou long bones for a makushan. Photograph by Georg Henriksen.

Among the Innu, there is an especially sacred fat-oriented feast, called the makushan, which is dedicated to caribou, and is focused on the leg bones. In preparation for the feast "the major caribou long bones (humerus, radio-ulna, tibia and femur) […] must be scraped clean of meat and underlying membranes, until they are almost whitened. The oil bearing nubs (epiphyses) are broken off, crushed into a paste and boiled in water to extract oil (Fig. 1.10). The bone mash fragments are drained and put into the fire. […], the shafts (diaphyses) between the nubs are cracked open, the marrow removed, cut into small pieces and then mixed with the rendered oil" (Jenkinson and Ashini, 2015: p. 19).

The above photograph illustrates that during the crushing of the bones a screen was used to ensure that no bone fragments were allowed to go astray. One person is assigned the role of ensuring that this preparation is done correctly, and a second individual oversees the serving of the makushan feast. Along with the congealed bone fat and marrow, bone broth from the boiling of the crushed bone ends is served. Elders of both genders are served first, followed by the rest of the people.

In the boreal forest region, most organic material rapidly decays in the acidic soil. Despite this, calcified caribou bone fragments have been found preserved in ancient fireplaces, dated as old as 6000 BP, that is, not long after the ice sheet retreated and humans first entered the region (Jenkinson and Ashini, 2015). This evidence suggests the practice of extracting fat from crushed bones is of great antiquity, while the fact that these remains were put in the fire suggests that, as is the case today, this material was considered a substance that should not be disposed of as garbage for scavengers to consume.

1.9 ONTOLOGY AND MATERIAL CULTURE

The above example of ancient piles of crushed and burned caribou bones is but one of many material traces of a pre-contact ontological perspective in relation to game animals. Other examples are the pictographs in the region, drawings on exposed rock faces, mainly along canoe routes, and which are found throughout the whole region occupied by northern Algonquians, a language family grouping that includes the Iyuu and the Innu. In the Iyuu area, for example, the *Kaapehpeshapis-chinikanuuch* site (literally "the place where figures are drawn on the rock") is an important one, as it features many kinds of images including game animals, humans, other kinds of beings and geometric patterns (Vaillancourt, 2008). While we do not fully know the makers' motivations for these drawings, many clearly refer to the Iyuu animist ontology. Moreover, some contemporary Iyuu attribute these drawings to non-human persons. According to two Iyuu elders "the paintings could have been made by the Memegwashio, the little hairy ones who used to live within the rock outcrops and cliffs, a long time ago" (Arsenault, 1998: p. 13).

These creatures are said to live inside rock cliffs, from which they emerge through doors that magically open, paddling canoes made of rock. At times these creatures are said to steal fish from the nets of the Iyuu.

Many other forms of rock or stone also have ontological significance for the Iyuu/Innu and their ancestors, as they do for many other hunter-gatherers (Boivin, 2004). Among the northern Algonqian peoples in general certain rocks are other-than-human persons. In this language family all nouns are either animate or inanimate. These labels were given by linguists because in this language most items that Western ontology would consider inanimate take the inanimate form. However, there are exceptions, including the term for rock or stone (*assini*), which takes that animate form. The implication is that for the Algonquian peoples stone, or specific stones, have the potential to be an other-than-human person (Hallowell, 1964: pp. 24–26).

While today the Iyuu and Innu have relatively few instrumental uses for stone compared to the past, they have maintained traditional knowledge of some kinds of stone and their uses. *Ayiipsk* is a particularly hard black stone that informants recall being shaped so it could be held in the hand and used for pounding and powdering dried meat. In the past stones of this type were also heated in the fire, and added to a pile of fat in a birch bark container so as to render the fat. This and other kinds of stone that have the quality that they do not crack or explode when made red hot would be heated for use in the sweat lodge. It is said that it is these rocks themselves that emit the healing power, rather than just the heat itself (Tanner, 2014: p. 187). Another kind of stone was called *mukman sinii* (knife stone), a black slate once used for making knives. Sisitchew is a kind of stone that comes in grey, black, red varieties, and which could be carved. This stone could also be called spawaakan sini (pipe stone), as it was sometimes used to carve pipes for smoking.

An especially noteworthy example of the value that Iyuu and Innu and their ancestors placed on certain kinds of rock involves a class of white quartz, referred to in the literature as either chert or quartzite. There are two particularly well-known pre-contact sites in Quebec-Labrador where this kind of material was obtained. One is at Ramah Bay in northern Labrador, the white chert from which was both used locally and traded widely over millennia (Loring, 2002; Bellavance, 2006), such that it has been found at sites all over Quebec-Labrador, as far south as Maryland and Virginia (Lowery, 2017) and as far west as the Ottawa region (Pilon and Boswell, 2015). At the Ramah quarry site there are also some very dark or "blackish" grades of chert, but it is apparent that the white grade was far more highly valued. The Innu name for Ramah chert is *uinnapishkanikan*, which translates as "stone that looks like subcutaneous fat". As we have noted above, fat is, for the Iyuu/Innu, an important substance, particularly in the ceremonial context of the makushan feast.

Figure 1.11: Antre de Marbre. Photograph David Denton.

A second source of a white stone was from the quartzite quarry at Colline Blanche (White Hill), just north of Lake Mistassini, in the Iyuu region of Quebec-Labrador. This stone has been found at pre-contact sites as far away as the St Lawrence valley and New England (Denton, 1998). The Iyuu/Innu marked its similarity to Ramah chert by its name, which in the Iyuu dialect is *wiinuwaapisk*, meaning "stone that looks like animal fat or lard" (Denton, 1998: p. 18). At this site there is a large cave whose size and white walls so impressed the first French explorers that they called it the "Antre de Marbre" – "The Marble Hall" (Fig. 1.11). These explorers also noted that the cave was used by Iyuu shamans, and as a place of worship. Archaeologists have shown that stone was being quarried at this site as far back as 7000 years ago, that is, soon after the glaciers retreated from the region (Denton, 1998: pp. 20–21). The cave is close to a well-used travel route, and present-day Iyuu elders recall stopping there on their travels and using the cave to hold feasts and dances, as well as for gathering some of the stones for strike-a-lites. The Iyuu name for the cave is *waapushukamikw*, meaning "house of the hare" (Denton, 2017). It is significant that the Iyuu term for the Arctic Hare (*waapush*) literally means 'the white one' (Zawadzka, 2011: p. 11), so that this name draws attention to the importance for the Iyuu of the white color of the rock that was obtained there. As will be noted below, there is an explicit association for the Iyuu/Innu between the color white and the *ahchaakw*.

Beyond their symbolic association with animal fat, both these kinds of white stone had aesthetic value for the Iyuu/Innu, in addition to their utility for tool making. Tools made from Ramah chert have been found in pre-contact graves, indicating that the material was highly valued. At the Maritime Archaic site at Port au Choix piles of white pebbles were buried next to human remains, which Tuck hypothesized were grave offerings (Tuck, 1976). It may be of relevance that the Ramah Bay quarry is in the same general vicinity as the "caribou mountain", the place to which, according to the Innu, the caribou withdraw themselves when they have been offended by some infraction of the rules of respect.

Apart from the connection between white stone and its fat-like appearance, the colour white has other associations within Iyuu/Innu ontology. In this language, colors are expressed as verbs, and the *waap* verbal element signifies "white". This element is found in the term for dawn, *waapan*, which could be translated as "it whitens, gets light". As one scholar has noted "White in Algonquian thought is often associated with daylight, the rising sun and the dawn spirit and thus east" (Zawadzka, 2011: p. 13).

Figure 1.12: Shaman's Cloak, attributed to Kowkachish (Manakanet), wife of Mestawapeo (Sam Rich). National Museum of the American Indian, Smithsonian Institution (Catalogue # 17/6575).

Where possible, Iyuu and Innu hunting camp dwellings tend to have their doorways facing the rising sun, hunters saying that it is propitious when they step out of their dwellings at dawn towards the east, as this is where the helpful ahchaakw come from. For this reason offerings are generally displayed towards the east.

Other kinds of rock or stone were also valued by the Iyuu/Innu. Ochre was used in some sacred contexts. There are several places, well known to the Iyuu/Innu, where ochre can be found, and in some cases this fact is marked in the indigenous toponyms. For example, the name of the present Iyuu village of Wemindji on the coast of James Bay is derived from the local term for ochre (*wiyimin*), and was previously known in English as "Paint Hills". On the other side of the peninsula the dialect name for ochre is *wunamun*, and the name of the present village of La Romain was derived from a local Innu toponym meaning "Ochre River". Quantities of red ochre have been found in Maritime Archaic sites from Labrador to New Brunswick and Maine, particularly in graves, and sometime in association with Ramah chert (Hood, 1993: pp. 164–166). Surovell et al. (this volume) found ochre in associated with Palaeoindian mammoth hunters' domestic artifacts.

The Iyuu/Innu used ochre to make paint, including for the pictographs referred to previously. Until recently certain items of animal hide clothing were painted with colorful designs, using both ochre-based paint and parts of other colours made from different clays or particular plants. The best-known examples of this Iyuu/Innu painted hide tradition are the famous Naskapi painted coats, approximately a hundred of which are now held in some of the best museums in Europe and North America (Burnham, 1992). These magnificently decorated coats may have been adapted from the shaman's cloak, a decorated caribou hide which the shaman used to attract caribou to approach the waiting hunters (Armitage, 1990: p. 57) (Fig. 1.12).

Some informants recall the method for making these paints. To prepare red paint, powdered ochre was boiled in water along with either scrapings from the underside of a beaver pelt or with scraping from a caribou leg tendons. The paint was ready for use when it became sticky. Another kind of red paint was made from scraping the bark of the red willow plant, called wiikuspii in the Iyuu language. This was used to paint wooden objects, such as toboggan front boards, snow shovels, and snowshoes. Other colors came from particular colored clays or certain plant material, mixed with binders, like fish eggs, to make paints.

Another Iyuu/Innu artifact painted with ochre, along with other colors, was the "ceremonial hide". Elders recall that it was made from the complete hide of an animal, cleaned until it was white, and on a cloudless early morning painted around the edges with designs to mark the ears, eyes, legs and tail of the original animal, and then exposed for just the time the sun takes to rise above the horizon. As noted above, the rising sun at dawn brings the helpful ahchaakw. These hides were later displayed facing east at the doorway during a feast (Tanner, 1984). The power of the sacred hide that came from exposure to the rising sun lasted one year, after which other sacred hide would be made. Other sacred objects that were painted, many with ochre paint, include drums that were played by hunters as they sung to the animals. Some of the animal skulls or antlers that were hung in the trees were also decorated. These kinds of decorations were intended as offerings to the ahchaakw.

The point to be drawn from the above examples is that there are many aspects of Iyuu/Innu ontology, particularly their animist relationship with game animals that shaped their practices, in some cases leaving behind material traces.

1.10 CONCLUSION

Of what relevance is the above ethnographic material to how Pleistocene hunters may have behaved towards megafauna? Let us assume that these hunters lived in egalitarian social groups, and had some form of an animist ontology. These two features are generally linked. Religious ontologies tend to harmonize with the form of social and political organization of the societies where they are found. Hierarchically organized societies tend to have hierarchically ordered gods and spiritual entities, as well as hierarchically ordered human specialists, such as priests, who act as intermediaries between the laity and the gods. By contrast, an animist ontology is horizontal and egalitarian, both in human interpersonal relations and in relations between hunters and animals. This arrangement harmonizes with a basically egalitarian society, including that of early hunter-gatherers.

We might further speculate that, as animists, the social basis of the relationship that early hunters had with these animals reflected the principle of reciprocity—that is, the attitude of "one good turn deserves another". This seems particularly likely to have been the case in their relations with elephants and mastodons, given that these were herbivores and thus not generally threatening to humans. Moreover, when they were killed, or their corpses found after they had died from other causes, they would have supplied hunting groups with huge quantities of meat and fat, as well as bones as raw material for tools. This would have been an occasion for celebration, for inviting other groups to share in the kill, and for feasting. It is also reasonable to speculate that this would also have been the occasion for symbolic acts of gratitude to the slain animal.

Iyuu/Inn hunters behave towards particular items associated with the hunt in ways that are designed to cultivate animate power. It seems that what empowers game also empowers certain iconic artifacts associated with the hunt, such as fat, stone, bone, hide and ochre. Hunters who were highly dependant on stone for making tools may well have attributed a special value to stone, as did the pre-contact Iyuu/Innu, including towards particular kinds of stone. As in the Iyuu/Innu case, this value attributed to stone would have been not only instrumental, but also aesthetic and as offerings to the game animals. Some Palaeolithic hunter-gatherers also had this kind of aesthetic relationship with stone, such as collecting pebbles whose value was simply that they were colorful (Assaf, 2018). While animism comes in many forms, the evidence from the Pleistocene, such as cave art and carvings, when put alongside the equivalent kinds of practices of recent hunters, suggests these hunters generally engaged with their game animals as powerful fellow persons. Based on both pre-contact and contemporary forms of expressive art and decoration, those artifacts that were offered as displays to the animist entities, like the painted hides, represents the aesthetic tastes and values of the human group. As stone tool makers, the ancestors of the Iyuu/Innu valued the forms of quartz from which they made tools, but in a way that combines the utilitarian, aesthetic and moral reciprocity with the game animals. They valued this white stone in part as one aspect of the celebration of their relationship with animals, by linking the stone with a substance that was sacred to them, animal fat.

My focus in the chapter has been on a group of hunter-gatherers that, in both time and living conditions, are a long way away from Pleistocene hunters of megafauna. While the former cannot serve as analogs for the latter, they, along with other recent and contemporary hunter-gathers, can act as sources of ideas to stimulate the analysis and understanding of these far more ancient peoples.

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1

The Palaeolithic record

2. HOMININS, MAMMOTHS, SABER-TOOTHS AND GIANT HYENAS IN THE EARLY PLEISTOCENE OF THE BAZA BASIN (SE SPAIN)

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ABSTRACT

The Baza Basin preserves an exceptional Plio-Pleistocene palaeontological record, which includes the earliest evidence of human presence in western Europe, dated to ~1.4 Ma, coming from the sites of Barranco León and Fuente Nueva-3, in the vicinity of the town of Orce. In this geographical region, early *Homo* coexisted and likely competed with the giant, short-faced hyena *Pachycrocuta brevirostris* for the exploitation of prey carcasses abandoned by saber-tooth cats (*Megantereon* and *Homotherium*). The presence of these hypercarnivorous felids favored the surviving of both scavenging species (*Homo* and *Pachycrocuta*), as they exploited their prey to a lesser extent than the living pantherine felids. In this context, proboscideans were an exploited food resource, as evidenced by the presence of a partial skeleton of the mammoth *Mammuthus meridionalis* in Fuente Nueva-3, which was surrounded by lithic artifacts and hyena coprolites. This association suggests that both hominins and hyenas fed on the mammoth carcass. Some paths for elucidating their pattern of access to these resources are also discussed.

2.1 INTRODUCTION

The Baza Basin (SE Spain; Fig. 2.1) is part of the Guadix-Baza Depression, a post-orogenic Neogene–Quaternary intramontane basin that was

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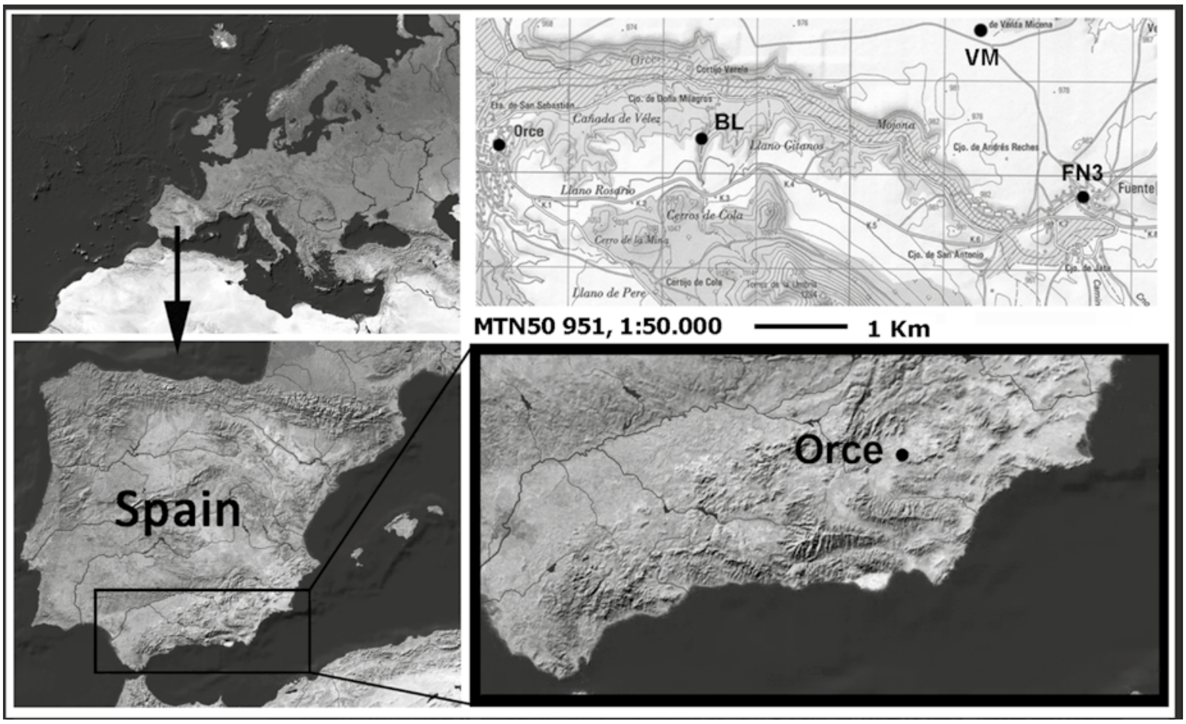

Figure 2.1: Geographic location of Venta Micena, Barranco León and Fuente Nueva-3. Sources: software MapCreator 2.0 free edition and topographic map from MTN50, 951 Instituto Cartográfico Nacional.

subject to endorheic conditions from the latest Miocene to the Middle Pleistocene, which resulted in a wide swampy and lacustrine setting. The entire sedimentary depression experienced during the Early Pleistocene intense hydrothermal activity in an active tectonic system. This is evidenced by the presence of many hot springs in the basin, some of them currently active (García-Aguilar et al., 2014, 2015). The contribution of thermal waters helped to maintain a relatively permanent water table with warm and stable temperatures throughout the year. This allowed the development of a well-diversified mammalian community, whose fossil remains are found in many palaeontological sites with chronologies that range from the latest Miocene to the Middle Pleistocene.

The early Pliocene is well represented in the Baza Basin, especially at the Ruscinian site of Baza-1, where two proboscidean species are present, the mammutid *Mammut borsoni*, and the gomphothere *Anancus arvernensis*. These megaherbivores are associated with other large mammals, including *Stephanorhinus* cf. *jeanvireti*, *Hipparion* sp., *Alephis* sp., cf. *Antilope* and Cervinae indet. In addition, there are microfaunal remains of 16 species of rodents, lagomorphs and insectivores, as well as reptiles, amphibians, fishes and birds (Piñero et al., 2017; Ros-Montoya et al., 2017).

The Early Pleistocene is well documented in many sites of the basin, especially in its north-eastern sector, in the vicinity of the town of Orce (Moyà-Solà et al., 1987; Martínez-Navarro, 1991; Arribas and Palmqvist, 1998; Palmqvist et al., 2011; García-Aguilar et al., 2014; Martínez-Navarro, 2018). Among these sites, Venta Micena (VM), Barranco Léon (BL) and Fuente Nueva-3 (FN-3) are particularly remarkable for the quality and quantity of their fossil record.

VM is a palaeontological site with an estimated chronology of ~1.6–1.5 Ma, which has provided a rich assemblage of large mammals of late Villafranchian age with an excellent preservation state. The faunal assemblage includes skeletal remains of 21 taxa of large (>10 kg) mammals. Taphonomic analysis has evidenced the involvement of the giant, short-faced hyena *Pachycrocuta* *brevirostris* in the bone accumulating process (see details in Arribas and Palmqvist, 1998; Palmqvist and Arribas, 2001; Espigares, 2010; Palmqvist et al., 2011).

BL and FN-3 are two localities that provide some of the earliest records of human presence in western Europe (Espigares et al., 2019). The age of these sites has been estimated by a combination of biostratigraphy and the U-series/ESR dating method at 1.43 ± 0.38 Ma for BL and 1.19 ± 0.21 Ma for FN-3 (Duval et al., 2012; Toro-Moyano et al., 2013), and there is also an age estimation of 1.50 ± 0.31 Ma for FN-3 derived from cosmogenic nuclides (Álvarez et al., 2015). In addition, the absence of suids suggests that both sites are older than 1.22 Ma (Martínez-Navarro et al., 2015). The evidence of human presence in BL and FN-3 includes the finding of a human deciduous tooth at BL (D Level), rich lithic Oldowan tool assemblages at both sites and abundant bones that show anthropogenic modifications, including cut and percussion marks related to carcass processing (Toro Moyano et al., 2011, 2013; Titton et al., 2018; Espigares et al., 2019). The faunal assemblages of these sites include 18 species of large mammals, 15 species of small mammals and 23 herpetofaunal taxa; some avian fossils have also been discovered (Table 2.1).

The presence of mammoths, saber-tooth felids and hyenas in the three sites, as well as the evidence of hominin occurrence at BL and FN-3, make these sites ideal case studies for their interactions during the Early Pleistocene in western Europe.

2.2 HOMININS

Early members of the genus *Homo* dispersed in the middle latitudes of Eurasia at ~2.0 Ma. Out of Africa, the earliest hints of human presence come from Shangchen (China) and Riwat (Pakistan), based on the presence of lithic artifacts, dated to ~2.12 Ma and ~1.9 Ma, respectively. Slightly younger, but more abundant, are the findings from Dmanisi in Caucasus, where a rich assemblage of Oldowan tools and skeletal remains of large mammals, including five hominin skulls, dated to ~1.8 Ma have been discovered (Lordkipanidze et al., 2013 and references therein). At ~1.6 Ma hominins are present in Majuangou III (Nihewan) and Gondwangling (Lantian), both in China, as well as in Mojokerto and Sangiran (Java, Indonesia) (Zhu et al., 2015, 2018). Later on, they arrive in western Europe, where their settlements are dated to ~1.5–1.4 Ma.

Evidence of early human presence in Europe is recorded in several sites, including Level TE9, Sima del Elefante in Atapuerca, Spain (~1.2 Ma), Pirro Nord in Italy (1.7–1.3 Ma), and Lézignan-la-Cèbe (1.3–1.1 Ma), Vallonnet (1.2–1.1 Ma) and Pont-de-Lavaud (~1.1 Ma) in France (Carbonell et al., 2008; Michel, et al., 2017; Cheheb et al., 2019). In this context, the two localities in the vicinity of the town of Orce, BL and FN-3, are very interesting, as they provide some of the earliest records of human presence in western Europe (Martínez-Navarro et al., 1997; Oms et al., 2000; Espigares et al., 2013, 2019; Toro-Moyano et al., 2013).

Insights on the subsistence strategies of the populations of early *Homo* suggest that their diet included probably a broad spectrum of resources, where meat and other animal products (e.g., bone marrow and viscera) constituted perhaps an important fraction of the daily caloric intake (Stanford, 1999; Bunn, 2007; Hardy, 2010; Bunn et al., 2017; Hardy et al. 2017; Prado-Nóvoa et al., 2017). The evolutionary trend in humans towards an increase of encephalization in parallel to a decrease in the size of the post-canine teeth is usually envisioned as evidence of the progressive adaptation of *Homo* to a higher quality, more carnivorous and more easily digestible diet than in other hominins, such as the australopithecines (Aiello and Wheeler, 1995; Bunn, 2001; Dunsworth and Walker, 2002; Jiménez-Arenas et al., 2012; Espigares et al., 2019). The adaptation to meat eating, which probably arose in Africa at the origin of the genus *Homo* at ~2.6 Ma, allowed the expansion of the dietary niche of these early populations (Speth,

Taxon	**Venta Micena**	**Barranco León**	**Fuente Nueva-3**	**Reference**
Aves indet.		x	x	Espigares, 2010
Discoglossus cf. *jeanneae*		x	x	Blain et al., 2016
Pelobates cultripes		x	x	Blain et al., 2016
Bufo bufo		x	x	Blain et al., 2016
Epidalea calamita		x		Blain et al., 2016
Bufotes sp.		x	x	Blain et al., 2016
Hyla sp.		x		Blain et al., 2016
Pelophylax cf. *perezi*	x	x	x	Blain et al., 2016
Anura indet.		x	x	Blain et al., 2016
Chalcides cf. *bedriagae*			x	Blain et al., 2016
cf. *Chalcides*		x		Blain et al., 2016
Timon cf. *lepidus*	x	x	x	Blain et al., 2016
Dopasia sp.		x	x	Blain et al., 2016
Ophisaurus sp.		x		Blain et al., 2016
Coronella girondica		x	x	Blain et al., 2016
Natrix maura	x	x	x	Blain et al., 2016
Natrix natrix		x	x	Blain et al., 2016
Rhinechis scalaris		x	x	Blain et al., 2016
Malpolon monspessulanus		x	x	Blain et al., 2016
Colubridae		x	x	Blain et al., 2016
Ophidien indet.		x		Blain et al., 2016
Emys cf. *orbicularis*		x		Blain et al., 2016
Mauremys cf. *leprosa*		x		Blain et al., 2016
Testudo sp.	x	x	x	Blain et al., 2016
Asoriculus gibberodon	x	x	x	Furió, 2010
Sorex minutus		x	x	Furió, 2010
Sorex sp.		x	x	Furió, 2010
Crocidura sp.		x	x	Furió, 2010
Erinaceus cf. *praeglacialis*		x	x	Furió, 2010
Galemys sp.	x	x	x	Furió, 2010
Mimomys savini		x	x	Agustí et al., 2010
Allophaiomys ruffoi	x			Agustí et al., 2010
Allophaiomys lavocati		x	x	Agustí et al., 2010
Allophaiomys sp.		x	x	Agustí et al., 2010
Castillomys rivas	x	x	x	Agustí et al., 2010
Apodemos sylvaticus	x			Agustí et al., 2010
Apodemus flavicollis		x		Agustí et al., 2010
Apodemus mystacinus	x		x	Agustí et al., 2010
Oryctolagus cf. *lacosti*	x	x	x	Agustí et al., 2010

Prolagus sp.	x	x		Agustí et al., 2010
Hystrix sp.	x	x	x	Agustí et al., 2010
Homotherium latidens	x			Martínez-Navarro, 1991
Megantereon whitei	x			Martínez-Navarro and Palmqvist, 1995
Panthera gombaszoegensis	x			Pons-Moyà, 1987
Lynx cf. *pardinus*	x		x	Boscaini et al., 2015
Pachycrocuta brevirostris	x	x	x	Pons-Moyà, 1987
Lycaon lycaonoides	x	x	x	Martínez-Navarro and Rook, 2003
Canis mosbachensis	x	x	x	Martínez Navarro, 2002
Vulpes cf. *praeglacialis*	x	x	x	Pons-Moyà, 1087
Ursus etruscus	x	x	x	Torres Pérez-Hidalgo, 1992; Medin et al., 2017
Pannonictis cf. *nestii*	x	x	x	Martínez Navarro et al., 2010
Meles meles	x	x	x	Madurell-Malapeira et al., 2011
Mammuthus meridionalis	x	x	x	Ros-Montoya et al., 2010
Stephanorhinus hundsheimensis	x	x	x	Lacombat, 2010
Equus altidens	x	x	x	Guerrero-Alba and Palmqvist, 1997; Alberdi, 2010
Equus sussenbornensis		x	x	Alberdi, 2010
Hippopotamus antiquus	x	x	x	Alberdi and Ruiz-Bustos, 1985
Bison sp.	x	x	x	Moyà-Solà, 1987
Hemibos cf. *gracilis*	x			Martínez Navarro et al., 2011
Soergelia minor	x			Moyà-Solà, 1987
Praeovibos sp.	x			Moyà-Solà, 1987
Hemitragus albus	x	x	x	Crégut-Bonnoure, 1999
Ammotragus europaeus			x	Moullé et al., 2004; Martínez-Navarro et al., 2010
Praemegaceros cf. *verticornis*	x	x	x	Abazzi, 2010
Metacervocerus rhenanus	x	x	x	Abazzi, 2010

Table 2.1: Vertebrate assemblages from Venta Micena (VM), Barranco Léon (BL) and Fuente Nueva-3 (FN-3).

1989; Bunn and Ezzo, 1993; Milton, 1999, 2000) and, as a consequence, their dispersal outside of Africa.

Herbivorous animals rely on plant biomass in the ecosystems, which ultimately depends on climate. Tropical latitudes are productive through the entire year with different kinds of plants, which in the past hominins could consume. However, when our ancestors arrived in the middle latitudes of Eurasia, they faced more seasonal conditions, where they relied possibly more on animal resources, especially during the cold season, when fruits and leaves were less available (Speth and Spielmann, 1983; Martínez-Navarro, 2010; Martínez-Navarro et al., 2014). Meat consumption by early *Homo* is evidenced by the finding in several Early Pleistocene localities of cut marks, percussion marks and fractures on bones, mostly belonging to large mammals, highlighting the importance of animal food for these populations.

Evidence of butchery can be confidently traced back to the origin of our genus or even earlier. In

Africa, the oldest cut marks associated with stone tools are recorded at Gona (Ethiopia) and are dated to 2.6–2.5 Ma (Semaw et al., 1997). Additionally, there are a number of Early Pleistocene localities from East and North Africa that preserve evidence of ancient anthropic activity, including Bouri (~2.5 Ma; de Heinzelin et al., 1999), Ain Boucherit (2.4–1.9 Ma; Sahnouni et al., 2018), Koobi Fora (~1.9 Ma; Bunn, 1997), FLK Zinj (Olduvai Gorge, ~1.8 Ma; Bunn and Kroll, 1986) and Ain Hanech (1.8 Ma; Sahnouni et al., 2013). However, the record of such evidence is not frequent. In Europe, the presence of cut marks and intentionally broken bones in BL and FN-3 provide key information on the dietary behavior of the first human settlers of western Europe (Espigares et al., 2013, 2019). Evidence of human presence in FN-3 and BL is well documented by the occurrence of rich assemblages of Oldowan artifacts (Turq et al., 1996; Martínez-Navarro et al., 1997), which include small-sized flakes (usually <2 cm), as well as cores and debris, made by flint and to a lesser extent by limestone (Toro-Moyano et al., 2011; Titton et al., 2018). These artifacts are associated to skeletal remains of large mammals (Table 2.1), of which a number preserve evidence of anthropogenic damage, such as cut marks (incisions, scrapes, sawing marks and chop marks) and percussion marks, related to the exploitation of carcasses for obtaining meat, fat and marrow (Espigares et al., 2019).

A subsistence strategy that included the consumption of animal resources obtained from the scavenging of ungulate carcasses, partially defleshed and abandoned by saber-tooth cats, has been proposed for the Early Pleistocene hominin populations that inhabited the Baza Basin (Martínez-Navarro and Palmqvist, 1995, 1996; Arribas and Palmqvist, 1999; Martínez-Navarro, 2004, 2010; Martínez-Navarro et al., 2014; Palmqvist et al., 2005, 2007, 2011; Espigares et al., 2013, 2019; Rodríguez-Gómez et al., 2016, 2017). This interpretation is based on the technological features of the lithic artifacts, which make it difficult to conceive that these populations had a direct impact on medium-to-large and very large ungulate prey using their small-sized Oldowan flakes (Blumenschine and Pobiner, 2007). Moreover, a scavenging behavior is supported by a mathematical model that estimates the meat that was available for the members of the carnivore guild, including the genus *Homo*, which in turn allows to evaluate the sustainability of the community of secondary consumers. After modelling three scenarios, the results obtained suggested a passive scavenging behavior as optimal for this population (Rodríguez-Gómez et al., 2016). However, this does not exclude other strategies of acquisition of animal foods, such as the opportunistic hunting of smaller mammals, the power scavenging of the prey of hypercarnivores (i.e., kleptoparasitism) or the scavenging of animal carcasses died from natural causes.

2.3 SABER-TOOTH CATS

The predator guild in the Early Pleistocene of Europe was dominated by two species of saber-tooth cats, *Megantereon whitei* and *Homotherium latidens* (Felidae, Machairodontinae). Martínez-Navarro and Palmqvist (1995, 1996) proposed that the arrival of *M. whitei* from Africa was the key factor that allowed the first hominin dispersal in Eurasia. This predator had a number of craniodental features, such as its relatively enlarged sabers and powerful forearms, as well as the extreme reduction of the premolar teeth and the short coronoid process (which indicates an increase in gape angle at the expense of a reduction in bite force), that suggest a capability to kill efficiently ungulate prey larger in relation to its own size in contrast to the extant pantherine felids of similar size. However, its highly specialized dentition for meat slicing suggests that this predator consumed only the soft tissues of its prey, leaving thus significant amounts of flesh on the prey carcasses and all within-bone nutrients. Compared to the living large felids, which are less hypercanivorous than the saber-tooth cats, this would result in greater quantities of animal resources available for the scavengers, including hominins and the giant, short-faced hyenas (Martínez-Navarro and Palmqvist, 1995, 1996; Arribas and Palmqvist, 1999; Martín-Serra et al., 2017; Palmqvist and Arribas, 2001; Palmqvist et al., 2003, 2007, 2008a, b, 2011; Ripple and Van Valkenburgh, 2010; Espigares et al., 2013, 2019; Martínez-Navarro, 2010; Martínez-Navarro et al., 2014; Van Valkenburgh et al., 2016).

The survival of saber-tooth cats in Europe helps to explain the persistence of Oldowan tools for nearly one million years more than in Africa (Palmqvist et al., 2005), as the sharp flakes were fully appropriate for scavenging the ungulate carcasses, partially defleshed by these felids, while the cores would have been useful for heavy-duty activities, such as bone-fracturing for accessing their marrow content (Plummer, 2004).

This scene changed during the Middle Pleistocene with the arrival of pantherine cats, which exploited their prey more intensively than saber-tooths. The new conditions implied a substantial change for the scavengers, the loss of a regular source of scavengeable animal foods and the replacement of the Oldowan technology by the more derived Acheulean tools (Arribas and Palmqvist, 1999).

2.4 *PACHYCROCUTA BREVIROSTRIS*

The Plio-Pleistocene short-faced hyena *Pachycrocuta brevirostris* was the largest bone-cracking carnivore mammal that ever existed. This giant hyena shows massive limbs with shortened distal bones (especially evident in the length of the tibia in relation to the length of the femur), and a heavy, powerfully built mandible with robust and well-developed premolars. The features of the postcranial skeleton suggest a less cursorial life style for *P. brevirostris* than the modern spotted hyena *Crocuta crocuta* as a result of its adaptation towards greater power and stability for dismembering animal carcasses and transporting large portions of them to the denning area (Turner and Antón, 1996), as evidenced in VM (Palmqvist and Arribas, 2001; Palmqvist et al., 2011).

The analysis of the preservation state of the skeletal elements modified by the giant hyenas evidences their highly specialized bone-cracking behavior, in agreement with the scavenging niche deduced for this species from the taphonomic analysis at VM. This site was interpreted as an accumulation by hyenas of portions of prey of flesh-eating carnivores in the surroundings of their maternity den (Palmqvist et al., 1996). The activity of *P. brevirostris* inserted a number of taphonomic biases in the bone assemblage. These resulted from the selective transport of ungulate carcasses and body parts, as a function of their body size, and also from the preferential consumption of those skeletal parts with lower density and greater marrow contents. This allows to define sequences of bone consumption for the different anatomical elements (i.e., a proximodistal sequence for humerus and tibia, a distoproximal sequence for radius and metapodials, and a less clearly defined pattern of consumption in the case of femur, which involves the fracturing of both bone epiphyses). Moreover, the high abundance of femoral diaphyses, and distal fragments of humeri and tibiae compared to other elements, is related with their marrow contents, which are greater than in the case of metapodials. The latter explains why these bones are more frequently preserved as complete elements (Arribas and Palmqvist, 1998; Palmqvist and Arribas, 2001; Espigares, 2010; Palmqvist et al., 2011).

The bone accumulations made by extant striped hyenas (*Hyaena hyaena*) show a similar preservation completeness of the ungulate skeletal remains to that recorded at VM (Skinner et al., 1980; Kerbis-Peterhans and Horwitz, 1992; Leakey et al., 1999) and this basic pattern applies to some extent also for those of spotted hyenas (Sutcliffe, 1970). This reveals an optimization of the benefit/cost ratio in the pattern of bone consumption by both extant and extinct bone-cracking hyenas. The dietary habits of *Pachycrocuta* may have been more similar to those of the brown (*Hyaena brunnea*) and striped hyenas, whose subsistence relies mainly on carrion, including a high percentage of bones, as evidenced by the huge accumulation of bones preserved at VM, and also by the relative dimensions of the bone-cracking premolars and carnassials (Palmqvist et al., 2008b). Moreover, in VM the taphonomic evidence suggests that the hyenas scavenged selectively the prey hunted by the hypercarnivorous saber-tooths and the painted dog *Lycaon lycaonoides* (Palmqvist et al., 1996). In summary, *P. brevirostris* exhibited a combination of body size and craniodental features, which suggests a mode of life based more on scavenging compared to the spotted hyenas (Palmqvist et al., 2011).

This interpretation, however, may have some problems. Striped and brown hyenas rely heavily on carrion (Rieger, 1981; Mills, 1982). Their postcranial skeleton is more lightly built than the spotted hyena one, owing to their need to prospect great distances in search of scavengeable carcasses. However, in the case of *P. brevirostris*, the large and robust body and the shortened distal limb segments represented probably a disadvantage for this mode of life. A plausible explanation for the strict scavenging behavior in this species is that *P. brevirostris* pursued other predators, for example *Megantereon whitei*, and exploited their prey acting as a kleptoparasite (Palmqvist et al., 1996, 2011; Arribas and Palmqvist, 1998; Palmqvist and Arribas, 2001).

2.5 MAMMOTHS AND THEIR INTERACTIONS WITH HOMININS AND HYENAS

The Baza Basin preserves one of the best Plio-Pleistocene records of proboscideans in Europe. Four species are documented: *Mammut borsoni* and *Anancus arvernensis*, and two mammoth species, *Mammuthus meridionalis* and *M. trogontherii* (Ros-Montoya, 2010). Moreover, in the nearby basins of Guadix and Granada, *Palaeoloxodon antiquus* and *Mammuthus primigenius*, are also respectively recorded (Ros-Montoya, 2010).

Mammut borsoni and *A. arvernensis* appear together in the Ruscinian site of Baza-1, dated to 4.5–4.0 Ma (Ros-Montoya et al., 2017). The latter species is also documented in the sites of Huéscar 3 and Canal de San Clemente (late Pliocene). Concerning the genus *Mammuthus*, *M. trogontherii* is recorded in the Middle Pleistocene site of Cúllar-Baza-1, whereas *M. meridionalis* is the best recorded proboscidean in the Baza Basin; remains of this species are present in at least eight sites, including VM, BL, FN-3, Barranco del Paso, Cañada de Vélez, Huéscar-1, Zújar and Cortes de Baza (Early Pleistocene) (Ros-Montoya et al., 2010, 2017, 2018).

Although there are several localities in the Baza Basin, where human presence has been documented, evidence of coexistence of hominins with proboscideans is recorded to date in only four of them: BL, FN-3, Huéscar-1 and Cúllar Baza-1. Among them, the site of FN-3 deserves a special attention, because it has provided remains of at least 10 *M. meridionalis* individuals of different ontogenetic ages, including neonates, juveniles, prime adults, adults and senile individuals (Ros Montoya, 2010).

One of the most remarkable findings in this site is a partial skeleton of an old female *M. meridionalis* individual, buried in a thick layer of fine sands that were deposited during a short sedimentary event. The skeleton preserves in anatomical connection the vertebral column, the pelvis, a scapula, some ribs and the mandible. In contrast, the fore- and hindlimbs, and the cranium are absent (Espigares et al., 2013). During the excavation of the skeleton, 17 lithic artifacts and 34 carnivore coprolites surrounding it were unearthed from the same stratigraphic level (Fig. 2.2).

The spatial and stratigraphic association of coprolites and flakes suggest that both hominins and hyenas fed possibly on the mammoth carcass. Although cut and tooth marks are absent from the preserved bones, their absence is not strange. Experiments on elephant bones show that butchery traces are rare and, in particular, cut marks on fossil proboscideans bones are scarce due to the thickness of the periosteum cover (Crader, 1983; Shipman and Rose, 1983; Haynes, 1991; Villa et al., 2005; Yravedra et al., 2010; Rabinovich et al., 2012). Similarly, evidence of carnivore tooth marks is also scarce in elephant bones (Haynes, 1988). For this reason, the absence of marks of biological origin, including those made by hominins and carnivores, does not imply that this type of resource was only used occasional. In fact, there are a number of sites in which human consumption of elephant carcasses has been proposed based on the presence of lithic tools associated to proboscidean remains with or without anthropogenic modifications on proboscidean bones, including Barogali in Djibuti (Chavaillon et al., 1987; Berthelet and Chavaillon, 2001), Olduvai in Tanzania (Leakey, 1971), Gombore II in Ethiopia, Mwanganda's Village in Malawi (Clark and Haynes, 1970), Revadim Quarry in Israel (Rabinovich et al., 2012), Notarchirico and la Polledrara di Cecanabbio in Italy (Piperno and Tagliacozzo, 2001; Mussi and Villa, 2008; Santucci et al., 2016), or Barranc de la Boella (Mosquera et al., 2015), Áridos and Torralba (Villa et al., 2005), and FN-3 in Spain (Espigares et al., 2013). In addition, the presence of elephant remains in caves, such as Bolomor cave in Spain, Ma'anshan cave in China and Spy cave in Belgium (Zhang et al., 2010; Blasco et al., 2013; Germonpré et al., 2014; Blasco and Fernández Peris, this volume), constitutes undisputed evidence of transport of selected anatomical portions of proboscideans by hominins.

At FN-3, flakes and coprolites surround the mammoth carcass and partly overlap, although both distributions are displaced (Fig. 2.2): the lithic artifacts are slightly more distant from the mammoth carcass than the coprolites, and most of them group in the front area of the skeleton; in contrast, the coprolites show a more homogeneous distribution around the mammoth, although they tend to concentrate on the right and back sides of the skeleton. These distributions were statistically tested (Espigares et al., 2013), and evidenced that coprolites and artifacts do not distribute randomly around the carcass.

An additional evidence that reinforces the argument that hyenas fed on the mammoth carcass is the color of these coprolites, which are darker than others unearthed in the site. This indicates that they were produced when the hyenas ate large quantities of meat and grease (Matthews, 1939; Bearder, 1977). In this regard, it is interesting to keep in mind that a spotted hyena can ingest one third of its body mass in only one meal (Kruuk, 1972).

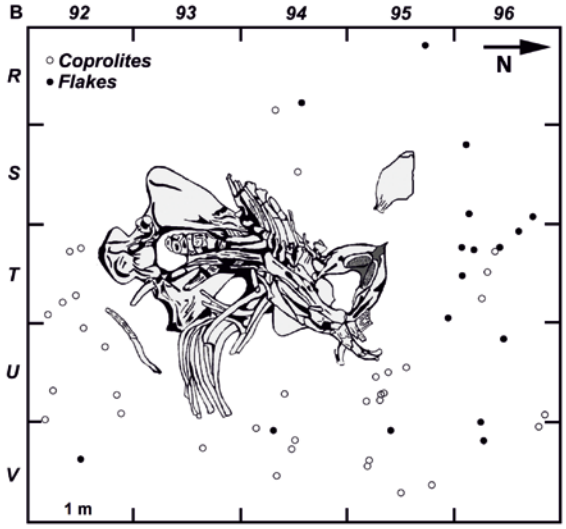

Figure 2.2: Partial skeleton of *Mammuthus meridionalis* from Fuente Nueva-3, and spatial distribution of coprolites and lithic artifacts surrounding it (modified from Espigares et al., 2013).

2.6 DISCUSSION AND CONCLUSIONS

Europe was characterized by a marked seasonality during most of the Pleistocene, with cooler and drier conditions than those of tropical Africa. For this reason, the availability of large carcasses constituted a critical resource for species with scavenging behavior, including the two major agents responsible for modifying and accumulating the skeletal remains of large mammals during this period: the giant, short-faced hyena *Pachycrocuta brevirostris* and early *Homo* (Turner, 1990, 1992; Turner and Antón, 1998; Arribas and Palmqvist, 1999). In this setting, the two species of saber-tooth cats (*Homotherium latidens* and *Megantereon whitei*) recorded in Early Pleistocene European assemblages, represented a fundamental component of the trophic chain, as their kills probably retained great amounts of flesh given their highly specialized dentition, thus opening broad opportunities for the scavengers (Martínez-Navarro and Palmqvist, 1996; Palmqvist et al., 2007).

In this context, the mammoth carcass from FN-3 described above represents possibly the first documented evidence of direct competition between *Homo* and *Pachycrocuta* for access to scavengeable resources (Espigares et al., 2013). The data obtained in the analysis of the spatial distribution of the lithic artifacts and coprolites that surround this skeleton, as well as the absence of some anatomical parts, such as the limbs and the cranium, allow us to speculate on the sequence of access of hominins and hyenas to the mammoth remains.

We hypothesize that hominins arrived first, probably favored by their most diurnal foraging habits, in contrast to the preferably nocturnal lifestyle of hyenas. This probably gave them a time lapse sufficient to avoid a direct confrontation with the giant hyenas, given that their body size and technological skills would hardly have allowed them to succeed in this situation. In addition, stone-throwing by hominins could have helped them in a fateful encounter with the hyenas. This speculative scenario has been suggested by Ferring (2011) for Dmanisi (Georgia), based on the great amount of allochthonous cobbles recovered at this site. This reasoning could apply also to FN-3, because abundant limestone cobbles are present at the site that could have been transported by hominins (Espigares et al., 2013). In addition, the time elapsed between the death of the mammoth and its consumption by the hominins should not have been very long, because the human digestive system is not adapted to consume rotten meat, whereas hyenas do not require this condition (Jones et al., 2016).

After their arrival to the mammoth carcass, the available evidence suggests that hominins probably dismembered and transported the limbs to another place. Experimental studies demonstrate that after the meat has been removed, one person can easily detach an elephant limb (Haynes, 1991: p. 185). Moreover, Figure 2.2 shows that some coprolites are placed in the areas that were presumably covered by the limbs of the mammoth, when the carcass was complete with all skeletal elements in anatomical connection, which reinforces our interpretation of their arrival to the carcass after the hominins.

The cranium and tusks are absent, and no cranial or ivory fragments have been found in the level where the mammoth was discovered. For this reason, it is not clear what happened to these elements. The absence of the atlas and part of the axis could be interpreted as evidence of detachment of the cranium, and the mandible would have been also disarticulated after the detachment of the masseter muscles for extracting the tongue. After that, the cranium could have been transported to a safer place for accessing the resources within it, since the proboscidean head bears a considerable amount of edible tissues, including the brain, the trunk, the temporal gland and the edible fat inside the air cavities that divide the cranium (Byers and Ugan, 2005; Shoshani et al., 2006; Agam and Barkai, 2016). After this, the hyenas probably exploited the rest of the carcass, composed mainly of the axial skeleton (Fig. 2.3).

This scenario changed in the transition from the Early to the Middle Pleistocene, which is known as the Mid-Pleistocene Revolution, when a faunal turnover took place. The extinction of *Megantereon* and other felids, such as the European jaguar (*Panthera gombaszoegensis*), the European cougar (*Puma pardoides*) and the giant cheetah (*Acinonyx pardinensis*), was preceded by the arrival of the modern pantherine cats, such as lions (*Panthera leo*) and leopards (*Panthera pardus*). Probably these new felids exploited their kills more in depth than the saber-tooths, which implied the loss of a regular source of prey carcasses for the scaven-

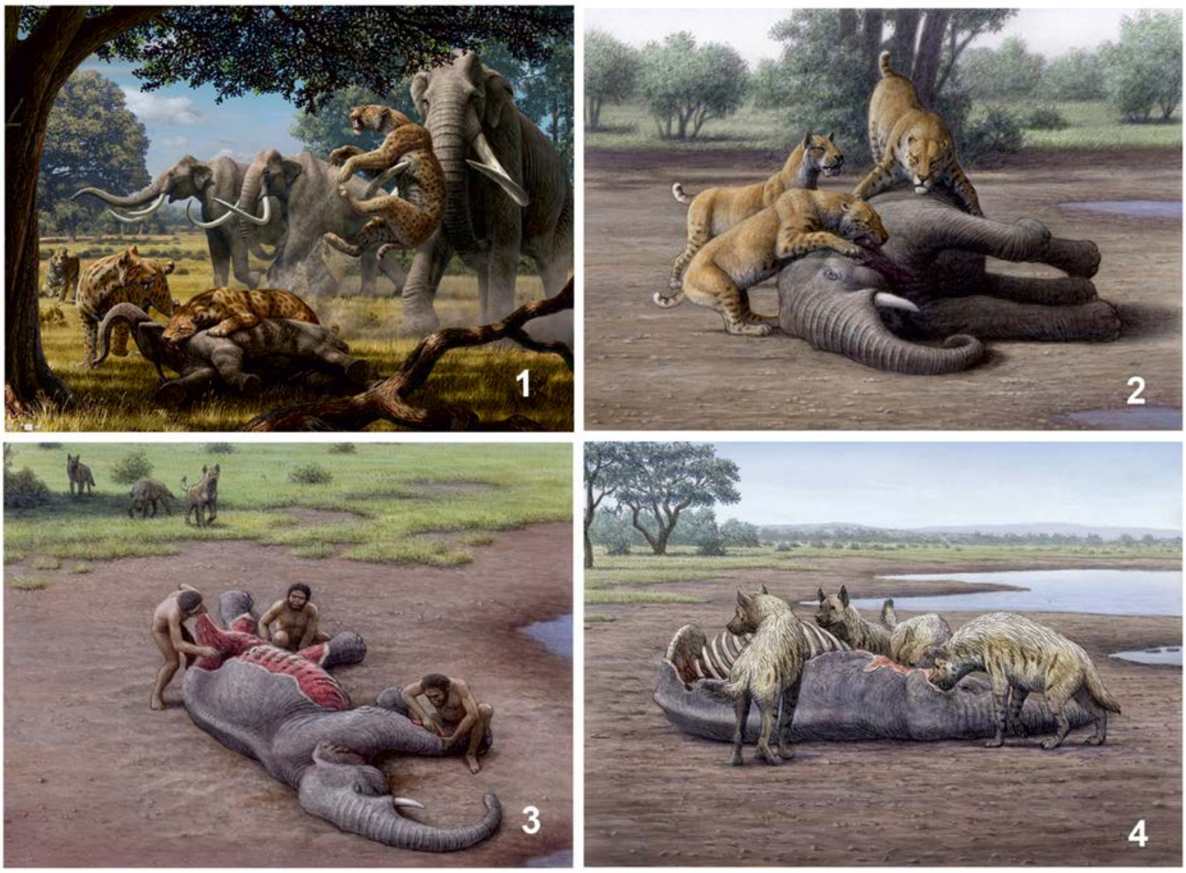

Figure 2.3: Sequence of interactions during the exploitation of the carcass of *Mammuthus meridionalis*. **1,** Reconstruction of hunting of mammoth calves by a saber-tooth pack (in this case, a juvenile of the North American *Mammuthus columbi*, preyed upon by the saber-tooth cat *Smilodon fatalis*). Hunting of mammoth calves by *Homotherium latidens* has been evidenced by isotopic analysis of bone collagen at Venta Micena (Orce, Baza Basin, SE Spain), a site in which the remains of juveniles of *Mammuthus meridionalis* are well represented (Palmqvist et al., 2008a, b). **2,** Hunting of an individual of *Mammuthus meridionalis* by *H. latidens*. Although there is no evidence for this interaction, the only carnivore able to subdue a megaherbivore of this size was this saber-tooth; however, there is always the possibility that the female mammoth of FN-3 died from starvation, as suggested by its highly worn third molar teeth. **3,** Scavenging of the mammoth carcass by the hominins. **4,** Scavenging by the hyenas. Drawings kindly provided by Mauricio Antón; images 1 and 2 from Antón (2013); images 3 and 4 from Espigares et al. (2013).

gers. In this new setting, the fate of the giant hyena, constrained by its highly specialized anatomy and a strict scavenging behavior, was extinction (Palmqvist et al., 2007, 2011).

In the case of the Middle and Late Pleistocene hominins, their further technological developments and new hunting techniques ensured that proboscideans continued to be an important source of food (Konidaris and Tourloukis, this volume), in addition as well of the use of their skeletal elements for other tasks (e.g., tusks and bones for dwelling structures) is well documented (Byers and Ugan, 2005; Demay et al. 2012; Iakovleva et al., 2012).

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3. PROBOSCIDEA-*HOMO* INTERACTIONS IN OPEN-AIR LOCALITIES DURING THE EARLY AND MIDDLE PLEISTOCENE OF WESTERN EURASIA: A PALAEONTOLOGICAL AND ARCHAEOLOCIGAL PERSPECTIVE

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ABSTRACT

In recent years, a significant number of Pleistocene localities with evidence of proboscidean exploitation by humans has been discovered, substantially enriching our knowledge on *Homo* subsistence strategies and megafauna acquisition. In this study, we provide a synthesis of the evidence for Proboscidea-*Homo* interactions in Early and Middle Pleistocene open-air sites of western Eurasia with direct (e.g., presence of cut marks, proboscidean bone artifacts, fractures for marrow extraction) and indirect (e.g., association and refitting of lithic artifacts, use-wear analysis) evidence of exploitation. Sex and ontogenetic age of butchered proboscideans are recorded, in order to assess possible human preferences. Furthermore, we investigate the role of large carnivores focusing on important renewals in the carnivore guilds, and their significance in terms of carrion availability for scavenging and human-carnivore competition for access to food resources. By applying an ecomorphological/behavioral approach, we examine the large carnivore community structure and dynamics, with emphasis in the hunting strategies of large predators. Additionally, we aim to infer their possible role in the changes of early human subsistence strategies focusing on proboscidean acquisition, and to explore the role of humans within the predatory guild. The ecological adaptations of the two common Middle Pleistocene proboscideans in Europe, the European straight-tusked elephant *Palaeoloxodon antiquus* and the steppe mammoth *Mammuthus trogontherii*, are also evaluated. Finally, we discuss various aspects of the *Homo* bio-cultural evolution during the period under study, including developments in material culture and relevant inferences about human social behavior.

3.1 INTRODUCTION

The last decades, a significant number of sites with evidence of anthropogenic exploitation of

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proboscideans has been discovered in western Eurasia, dating to the Early and Middle Pleistocene, considerably increasing our knowledge on *Homo* subsistence strategies. Proboscideans, the largest terrestrial animals during the Pleistocene, were widely distributed on all continents (apart from Antarctica and Australia). Although they constituted an ideal food package and therefore an attractive target for early humans (Ben-Dor et al., 2011; Reshef and Barkai, 2015; Agam and Barkai, 2016), their enormous size would have demanded the employment of special obtainment/exploitation methods and coordinated effort by a group of people, as well as investment of energy and time (Lupo and Schmitt, 2016). Assessing the human agency in proboscidean-bearing faunal assemblages is not always straightforward. First, the stratigraphic association of proboscidean and cultural remains does not in itself necessarily imply anthropogenic processing of carcasses and the verification of their functional relation requires taphonomic analysis (e.g., Giusti et al., 2018; Giusti, this volume). Second, hominin exploitation of carcasses can be difficult to demonstrate, because bone modifications can result from other (non-human) agents, human-induced cut marks are only rarely preserved, and possible subsequent weathering or other natural processes may delete direct evidence on bone surfaces (e.g., Haynes and Klimowicz, 2015). Despite these impediments, the Proboscidea-*Homo* interactions are relatively well recorded in the Pleistocene of western Eurasia. The objective of this study is to evaluate the Proboscidea-*Homo* record in open-air continental localities during the Early and Middle Pleistocene of western Eurasia, and to assess emerging patterns between ecological, ethological, environmental and cultural parameters.

3.2 METHODS

We included in our study 35 open-air sites from western Eurasia, dated from the Early until the Middle/Late Pleistocene boundary, and ranging from ~1.3 Ma to ~120 ka (Eemian Interglacial), thus covering the Lower and the early Middle Palaeolithic periods. We selected proboscidean single- and multi-carcass localities, as well as key localities where proboscideans constitute an important faunal element of the large mammal assemblage, in which human presence is indicated by the occurrence of human fossils, lithic/wooden artifacts and/or anthropogenic bone modifications. Their geographic position and chronology are shown in Figures 3.1 and 3.2, and Appendix 3.1. For each locality the parameters that we recorded are: Marine Isotope Stage (MIS; glacial/interglacial); proboscidean taxon; direct evidence of processing (cut marks, breakage for brain/marrow extraction, proboscidean bone tools, weapons associated with proboscidean skeleton); cut-marked/fractured skeletal element and purpose of modification; indirect evidence (presence of lithic/wooden artifacts, refitting of lithics, use-wear analysis, human fossils); lithic technology; bone artifacts; gender and ontogenetic age of the proboscidean individual; presence of large carnivores; occurrence of carnivore gnawing and coprolites; and associated large mammals (Appendix 3.1). In examining the sites, we do not directly compare data on mortality patterns, body part representation, site taphonomy and lithic or bone assemblages, because of discrepancies and/or information shortage in the published datasets.

Several studies analyzing the ecomorphology and guild structure of carnivores have been conducted, mainly as a tool to infer palaeoenvironmental conditions (Morlo et al., 2010 and references therein), but also to investigate carnivore communities during the Plio-Pleistocene and/or correlate them with early human settlements in Europe (e.g., Turner, 1992; Croitor and Brugal, 2010; Palombo, 2016; Rodríguez-Gómez et al., 2017). Here, we introduce a modified version of the three-dimensional ecomorphological approach of Morlo et al. (2010) in order to: 1) examine the community structure and dynamics (with emphasis on hunting strategy) of the large predatory guild of Europe during the Early and

Figure 3.1: Map showing the location of the studied open-air Early–Middle Pleistocene sites of western Eurasia with Proboscidea-*Homo* interactions (made with Natural Earth, naturalearthdata.com).

Middle Pleistocene, 2) infer the possible role of large carnivores in the changes of early human subsistence strategies (passive/active scavenging and hunting), with emphasis on megafauna acquisition and in particular proboscideans, and 3) assess the position and role of humans within the predatory guild. We combine four ecomorphological/behavioral parameters of carnivores (body mass, diet type, hunting strategy, sociality), which are presented by three-dimensional guild structure diagrams (Fig. 3.3b). We used only large carnivores, >~20 kg (Carbone et al., 2007), that practice hunting and/or scavenging on large prey, with only exception the large-sized mustelid *Gulo gulo* (wolverine), which although its average body mass is <20 kg (but >10 kg), it preys on mammals much larger than its size (MacDonald, 2009). We excluded small-sized mustelids, felids (*Felis*) and canids (*Vulpes*), with a weight <10 kg, because their meat consumption relies mainly on small vertebrates and the processing time for each of their prey is short. We ruled out as well the cave bears *Ursus deningeri* and *U. spelaeus*, because they were predominantly herbivorous, with occasional but no systematic scavenging/hunting behavior (Bocherens et al., 2011; van Heteren, 2011). However, we included the omnivores Asian black bear (*U. thibetanus*) and brown bear (*U. arctos*), because their diet includes ungulates, and both species are reported to exhibit hunting and more commonly scavenging behavior (MacDonald, 2009; Saladié et al., 2013; Pappa et al., 2019 and references therein). We separated carnivores into two chronofaunas: 1.8–1.0 Ma (within Early Pleistocene) and 500–300 ka (within Middle Pleistocene); the former includes the carnivores that were present during the first human colonization of Europe, and the latter involves a time when human presence is well recorded in various localities almost throughout the continent. The estimated body mass (BM) of carnivores is taken from Meloro et al. (2007), Palmqvist et al. (2011), Hemmer et al. (2011), Van Valkenburgh et al. (2016) and Rodríguez-Gómez et al. (2017). Three BM classes were defined, keeping the large-sized classes of Morlo et al. (2010): 1. 10–30 kg, 2. 30–100 kg, and 3. >100 kg. Diet was classified into four categories based on Van Valkenburgh (1988) and Morlo et al. (2010): 1. hypocarnivorous (includes the omnivores, <50% meat with non-vertebrate material predominating), 2. carnivorous (50–70% meat supplemented with non-vertebrate material), 3. hypercarnivorous (>70% meat), and 4. bone/meat (>70% meat with the addition of bones). Diet data were modified from Palombo (2016). Four foraging behavior groups (carcass acquisition strategy) have been distinguished following Werdelin (1996): 1. pursuit carnivore, 2. "stalk-and-ambush", 3. "ambush-and-slash", and 4. scavenger. Hunting strategy data were modified from Palombo (2016). Sociality is distinguished into: 1. social (group/pack-hunting), and 2. solitary, acknowledging, however, the flexibility of fission/fusion sociality. Sociality data were acquired from Treves and Palmqvist (2007) and Palombo (2016). The dataset is given in Table 3.1.

3.3 THE RECORD OF PROBOSCIDEA-*HOMO* INTERACTIONS

In this section we briefly present some key localities, where more systematic studies on Proboscidea-*Homo* interactions have been conducted, but the reader is referred to Appendix 3.1 and the references cited therein for more detailed accounts, as well as for the whole set of sites considered in this study.

3.3.1. LATE EARLY PLEISTOCENE (~1.8–0.78 MA)

The oldest-known Proboscidea-*Homo* event in Europe is attested at the Upper Archaeological Level of Fuente Nueva-3 (Spain), with an estimated age of ~1.3 Ma (1.19 ± 0.21 based on U-series/ESR dating; 1.50 ± 0.31 Ma from cosmogenic nuclides; Espigares et al., 2013; this volume and references therein). The discovery of a partial skeleton of the southern mammoth *Mammuthus meridionalis*, in association with lithic artifacts of "Mode 1" character and coprolites of the hyena *Pachycrocuta brevirostris* was interpreted as possible competition for scavenging between *Homo* and *Pachycrocuta* (Espigares et al., 2013; this volume). At Barranc de la Boella (Spain; 960–781 ka), the remains of a *M. meridionalis* skeleton, including two cut-marked ribs, were found together with lithic artifacts and were interpreted as representing a butchering event (Vallverdú et al., 2014; Mosquera et al., 2015).

3.3.2. MIDDLE PLEISTOCENE (0.78–0.12 MA)

In Gesher Benot Ya'aqov (Israel; 780 ka, MIS 19) a cranium of *Palaeoloxodon antiquus* (or perhaps *P. recki*) was discovered in association with Acheulean lithic artifacts; a basalt core, a boulder and an oak log that were found below the cranium, were possibly used to invert it. The upside-down position of the cranium, the missing basicranial and palatal regions, and the damage below the nasal opening, were attributed to possible deliberate brain extraction and trunk removal (Goren-Inbar et al., 1994). A similar case may also be represented in Notarchirico (Italy; 670–610 ka, MIS 16). In this locality, a cranium of *P. antiquus* was lying in an overturned position, lacking the masticatory apparatus and the occipital, and the mandible was found some meters away, indicating possible anthropogenic utilization of the brain, the tongue and the trunk (Piperno and Tagliacozzo, 2001). The lithic assemblage includes bifaces, however,

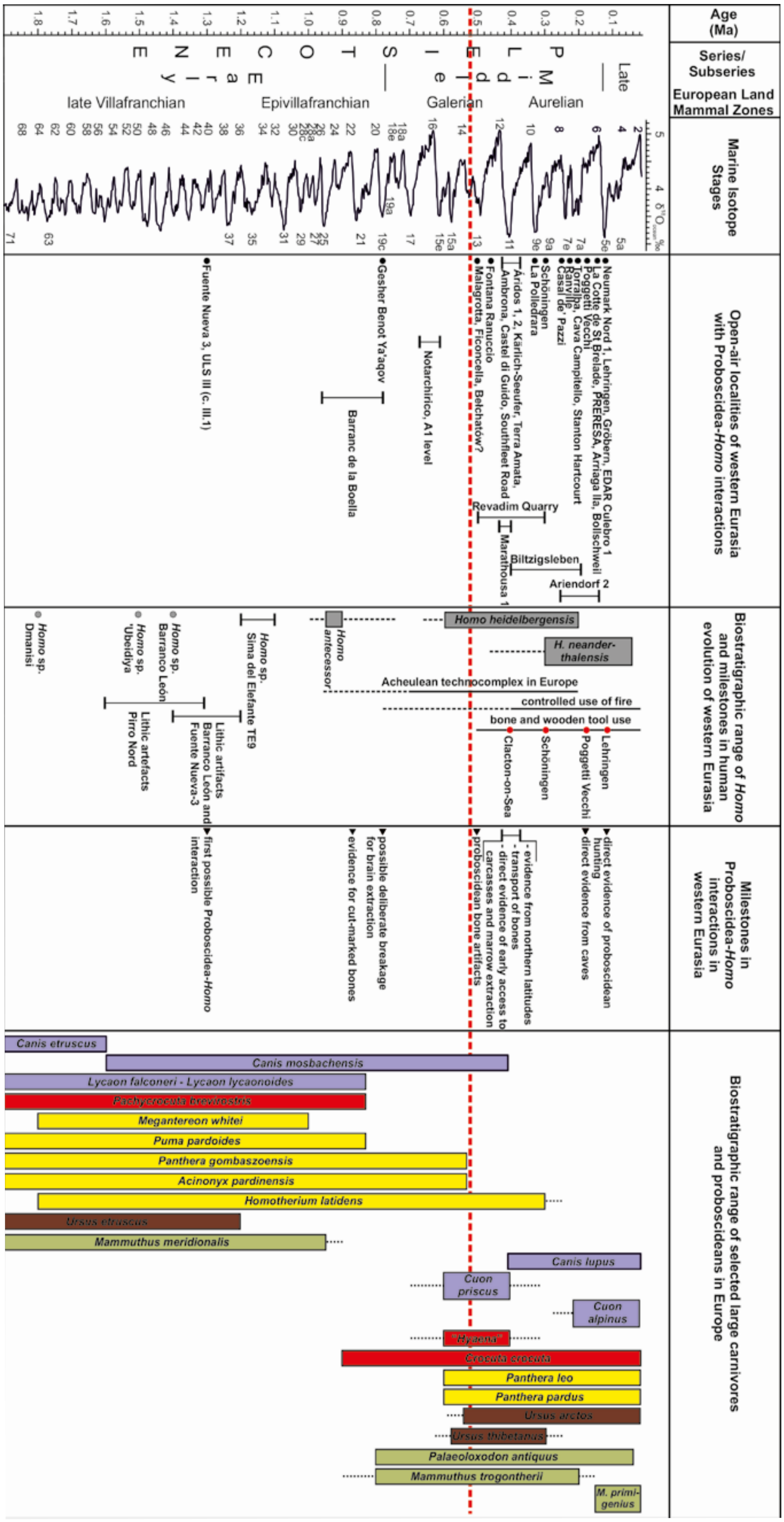

Figure 3.2: Chronology of the studied localities, biostratigraphic range of *Homo*, carnivores and proboscideans, and milestones in human evolution and Proboscidea-*Homo* interactions in western Eurasia.

the association between lithic artifacts and bones is not clearly demonstrated (Moncel et al., 2019).

In Ficoncella (Italy; ~500 ka, MIS 13), the discovery of a *P. antiquus* partial skeleton bearing carnivore gnawing and a small-tool lithic assemblage (with refits), indicates human occupation and *in situ* knapping events, as well as carnivore access to the carcass (Aureli et al., 2015). In Marathousa-1 (Greece; 500–400 ka, probably close to MIS 12/11 transition; Panagopoulou et al., 2018 and references therein), a partial skeleton of *P. antiquus*, and isolated elephant and other vertebrate remains were found in spatial and stratigraphic association with a small-tool lithic assemblage and bone artifacts (Konidaris et al., 2018; Tourloukis et al., 2018). Cut marks on the tibia and astragalus of the elephant skeleton, as well as on isolated elephant ribs (accompanied with peeling) and on other mammal bones, indicate butchering activities (Konidaris et al., 2018). A bone percussor, most likely made from an elephant limb bone, is also documented at this site (Tourloukis et al., 2018).

In Áridos 2 (Spain; ~380 ka, MIS 11), there is a strong human exploitation signal on the elephant bones: here, remains of a *P. antiquus* were associated with lithic tools, and the presence of cut marks on the scapula and on one rib suggest butchering activities. Their location on the bones indicates defleshing and evisceration, the latter pointing to early access to the carcass by humans before carnivores accessed it, leaving tooth marks and furrowing on the bones (Yravedra et al., 2010). In Ambrona (Spain; >350 ka, MIS 11), large mammals, most notably *P. antiquus*, were identified in several stratigraphic units. Of particular interest is the AS3 unit, where several elephant specimens were discovered, including a partial elephant skeleton. Human modifications were not detected on the skeleton; however, a cut mark was identified on another cranium, and two femoral shafts show anthropogenic fractures (Villa et al., 2005). The taphonomic analysis indicated that Ambrona represents a combination of natural accumulations and activities of humans, who regularly visited the site for exploiting elephants and other mammals (Villa et al., 2005). In Southfleet Road (England; ~425–375 Ma, MIS 11), a *P. antiquus* partial skeleton was found without direct evidence of anthropogenic activity. However, the tight spatial association between lithic artifacts and elephant bones, as well as the lithic refits and edge damage on some lithics, which probably resulted from on-site production and subsequent use as butchery tools, altogether indicate butchering activities (Wenban-Smith, 2013). In Castel di Guido (Italy; ~412 ka, MIS 11), abundant remains of *P. antiquus* and other mammals (notably the auroch *Bos primigenius*) were associated with Acheulean lithic artifacts; human bones were also discovered at the site. The locality represents a complex palimpsest formed by natural processes, human activities and minor carnivore involvement (Boschian and Saccà, 2010; Saccà, 2012). In addition to the exploitation of elephants for meat and marrow, elephant bones served as raw material for shaping tools, including bifaces. In the levels of Terra Amata (France; MIS 11), several *P. antiquus* remains were discovered in association with lithic artifacts; in addition to red deer hunting and carcass transport, young elephant remains were also transported to the site (Valensi et al., 2011).

In La Polledrara di Cecanibbio (Italy; ~325 ka, MIS 9), a great amount of *P. antiquus* remains were discovered, accompanied by a diverse mammal fauna rich in *Bos primigenius*; additionally, a deciduous premolar is attributed to *Homo heidelbergensis* (Anzidei et al., 2012). Of great interest are the remains of an elephant, which was possibly trapped in muddy sediments and exploited by humans (Santucci et al., 2016). A rich lithic industry was produced at the site (refitting, knapping debris) and the use-wear analysis indicates butchering activities. Human modifications on elephant bones include intentional fractures and removals, as well as production of bone tools (Anzidei et al., 2012; Santucci et al., 2016). In Revadim Quarry (Israel; ~500?–300? ka) several specimens of *P. antiquus* were found together with other faunal remains and a rich lithic assemblage. Among the elephant bones, one scapula and two ribs bear cut marks indicative of filleting, and others have been shaped to tools (Rabinovich et al., 2012). The interpretation of butchering activities at Revadim is further supported by use-wear and fat residue analyses (Solodenko et al., 2015).

In Poggetti Vecchi (Italy; MIS 7/6), wooden (digging sticks), bone (including elephant ones) and lithic artifacts were found in association with vertebrate remains; several *P. antiquus* individuals possibly died due to a natural cause and were subsequently exploited by humans (Aranguren et al., 2019). The Layers 3 and 6.1 of La Cotte de St Brelade (England; MIS 6) preserve evidence for megafauna exploitation (wooly mammoths and rhinos). Some mammoth bones show cut marks, while there exist also indications for brain extraction (rib driven into the cranium) (Smith, 2015). In PRERESA (Spain; MIS 6), bones of an elephantid individual show, in addition to cut marks, green fractures and percussion damage indicative for marrow extraction (Yravedra et al., 2012, 2019). The earliest so far known evidence for the use of wooden weapons in proboscidean hunting dates close to the Middle/Late Pleistocene boundary and is attested at Lehringen (Germany; ~120 ka, MIS 5e), where a wooden lance was discovered within a *P. antiquus* skeleton, associated also with lithic artifacts (Weber, 2000).

3.4 DISCUSSION

3.4.1. CARNIVORE GUILDS AND HOMININS

Shortly after the first “out of Africa” human dispersal, documented at Dmanisi (Georgia, ~1.8 Ma), and contemporaneous with the first appearance of humans in Europe (~1.3 Ma), the first association of a proboscidean skeleton with lithic artifacts in western Eurasia is documented at Fuente Nueva-3 (~1.3 Ma), where a possible competition between humans and *Pachycrocuta brevirostris* for scavenging a mammoth skeleton was suggested (Espigares et al., 2013). With a powerfully built body, mass nearly twice that of the spotted hyena *Crocuta crocuta* and unique craniodental features, the giant hyena *P. brevirostris* was well adapted for dismembering carcasses and consuming bones, and was the most direct competitor of *Homo* for scavenging large mammal carcasses during the Early Pleistocene (Martínez-Navarro, 2010; Palmqvist et al., 2011). *Pachycrocuta* and Homo were highly dependent on flesh-eating predators, such as the saber-toothed cats *Megantereon whitei* and *Homotherium latidens*, which were well adapted to hunt, but possibly ate mainly the soft parts of their prey (especially of large carcasses like proboscideans), leaving behind food resources (leftovers) that could be afterwards scavenged (Turner, 1992; Martínez-Navarro, 2010; Palmqvist et al., 2011; see also Blumenschine, 1987 for large herbivores and for proboscideans in particular). In particular, *Homotherium* groups were able to hunt (having cursorial adaptations), disarticulate, transport and deflesh very large prey (~5,700 kg) compared to their own size, including juveniles, adult female and young adult male proboscideans (Rawn-Schatzinger, 1992; Marean and Ehrhardt, 1995; Hemmer, 2001; Palmqvist et al., 2003, 2011; Van Valkenburgh et al., 2016; Barnett et al., 2020). But the large carnivore guild of the European Early Pleistocene was much more diversified, and apart from *Pachycrocuta*, *Megantereon* and *Homotherium*, included wolves (*Canis etruscus*[1]-*C. mosbachensis*), wild dogs (*Lycaon falconeri*-*L. lycaonoides*), bears (*Ursus etruscus*), lynxes (*Lynx issiodorensis*), jaguars (*Panthera gombaszoegensis*), giant cheetahs (*Acinonyx pardinensis*) and puma-like cats (*Puma pardoides*)[2], each of them equipped with great hunting, killing or scavenging

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[1] In Dmanisi the recently described *Canis borjgali*.

[2] The sympatry of these 10 large carnivores is recorded at Untermassfeld (Germany; *Ursus* cf. *dolinensis* instead of *U. etruscus*) and these are present collectively in the various sedimentary units of Pirro Nord (Italy). Other localities rich in large carnivores (≥7 species) include Dmanisi (Georgia), Apollonia-1 (Greece), Venta Micena, Cueva Victoria, Vallparadís Estació (all Spain), Ceyssageut and Vallonnet (both France); Cueva Victoria, Vallparadís Estació and Vallonnet with *U. deningeri* instead of *U. etruscus*. All sites include *Pachycrocuta* and saber-toothed felids, and yielded also *Mammuthus meridionalis*; Pirro Nord includes lithic artifacts; Dmanisi both lithic artifacts and human remains.

capabilities, and dental specializations related to their diet preferences; some of them were are also characterized by social foraging behavior (Fig. 3.3b, Table 3.1). Therefore, as a member of the predatory guild[3], encompassing 10 large carnivores, early *Homo* (estimated BM: 40–65 kg, stature: 145–155 cm; based on Dmanisi specimens; Gallagher, 2013) would have been positioned below the median of body mass of the carnivores (Fig. 3.3a), much smaller or nearly equal to 5 felids and *Pachycrocuta*, and only larger than the lynx and the canids; the latter, however, are pack-hunters (allowing them to kill prey much larger than their own size and larger than what a single individual would succeed) and, like the other large carnivores, also faster-running than *Homo*. This means that early humans had to confront and compete constantly, if they were to regularly exploit animal resources. Although the carnivores of that period occurred at low densities in Southern Europe, based on the low number of prey species (moderate herbivore biomass; Rodríguez and Mateos, 2018), we can assume that prime and undefended carcasses would have been rather rare (in particular the small- to medium-sized ones; Blumenschine, 1987), considering also the high diversity of large carnivorous/hypercarnivorous/bone-cracking predators, particularly with *Pachycrocuta* (the most important agent of bone accumulations during the Early Pleistocene of Eurasia; Martínez-Navarro, 2010) being present at the kill sites soon after the event, as it happens with recent hyenas (Domínguez-Rodrigo, 2001; Van Valkenburgh, 2001). This would result in relatively high competition for carcass acquisition, both among carnivores, and between carnivores and humans. Therefore, although early *Homo* could have taken advantage of naturally died proboscideans before carnivores discovering them, and in lack of strong evidence for elaborate hunting weaponry or techniques, we can assume, in particular for megafauna carcasses, that: a) access of early *Homo* to carcasses would have been possible mainly through passive scavenging of an already consumed and abandoned carnivore kill, and perhaps more possibly through active (confrontational/kleptoparasitic) scavenging (Blumenschine, 1987; Espigares et al., 2013; Madurell-Malapeira et al., 2017), and b) food acquisition and exploitation, carcass- and self-defense especially in the shadow of the fierce scavenger *P. brevirostris* would have been impossible without a certain degree of cooperation, social intelligence, and use of "weapons", even if these were still relatively simple (see also Agam and Barkai, 2018). Indeed, the scenario of stone-throwing for intimidating other carnivores was proposed for Dmanisi and Fuente Nueva-3, based on the abundant cobbles associated with mammal fossils (Espigares et al., 2013).

From the end of the Early Pleistocene/beginning of Middle Pleistocene and until ~0.6 Ma, an important faunal turnover took place, which involved the disappearance of several Villafranchian/Epivillafranchian taxa and the arrival of new immigrants (Galerian fauna), including also carnivores and proboscideans (Palombo, 2014). In proboscideans, the latest appearance of *Mammuthus meridionalis* is documented at ~900–800 ka, while around that time the steppe mammoth *M. trogontherii* and the European straight-tusked elephant *Palaeoloxodon antiquus* appear in Europe, increasing the number of proboscidean representatives.

In carnivores, the most prominent event is the extinction of *Pachycrocuta* and the arrival of *Crocuta crocuta* ("*Crocuta crocuta* event"). The last appearance of *P. brevirostris* is traced at ~800 ka, while the oldest European records of *C. crocuta* are documented at ~900–800 ka (Palombo, 2014). The extinction of *P. brevirostris* and the survival of *C. crocuta* are possibly attributed to ecological reasons: the super specialist scavenger *P. brevirostris* could not survive in the changing climatic conditions of the Middle Pleistocene, in which the more generalist and social hunting/scavenging *C. crocuta* could

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[3] In the European Early Pleistocene, percussion and cut marks, although occasional, thus suggesting a more opportunistic behavior, prove that meat, fat and marrow were integral part of early human diet. Human modifications are recorded on bones from a wide range of animal body sizes, including both slow and fast prey, which indicates a generalist behavior. In the discussion that follows, our premise is that Early Pleistocene *Homo* can be considered as a member of the large predatory guild, to which we also refer as "carnivore guild".

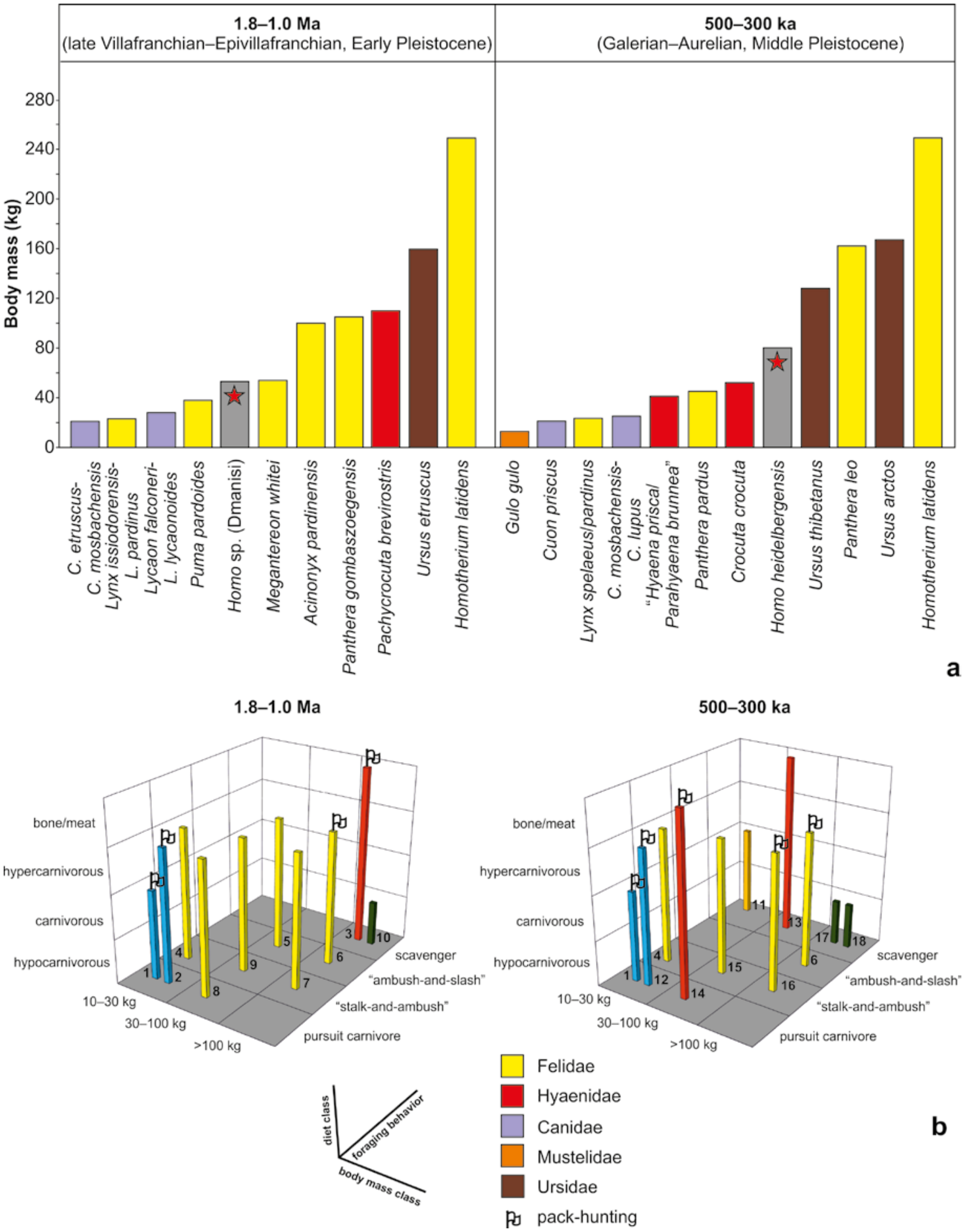

Figure 3.3: **a**, body mass distribution of large carnivores and *Homo* and, **b**, 3D guild structure diagrams of large carnivores, for 1.8–1.0 Ma and 500–300 ka in Europe. The numbering and the groups in (b) is according to Table 3.1.1, *Canis etruscus-C. mosbachensis-C. lupus*; 2, *Lycaon falconeri-L. lycaonoides*; 3, *Pachycrocuta brevirostris*; 4, *Lynx issiodorensis-L. pardinus*; 5, *Megantereon whitei*; 6, *Homotherium latidens*; 7, *Panthera gombaszoegensis*; 8, *Acinonyx pardinensis*; 9, *Puma pardoides*; 10, *Ursus etruscus*; 11, *Gulo gulo*; 12, *Cuon priscus*; 13, ''*Hyaena prisca/Parahyaena brunnea*''; 14, *Crocuta crocuta*; 15, *Panthera pardus*; 16, *Panthera leo*; 17, *Ursus thibetanus*; 18, *Ursus arctos*.

	Family	**Species**	**Body mass (kg)**	**Diet class**	**Hunting behavior**	**Sociality**
1.8–1.0 Ma (late Villafranchian–Epivillafranchian, Early Pleistocene)						
1.	Canidae	*Canis etruscus-C. mosbachensis*	10–30	carnivorous	pursuit carnivore	pack
2.	Canidae	*Lycaon falconeri-L. lycaonoides*	10–30	hypercarnivorous	pursuit carnivore	pack
3.	Hyaenidae	*Pachycrocuta brevirostris*	>100	bone/meat	scavenger	pack
4.	Felidae	*Lynx issiodorensis-L. pardinus*	10–30	hypercarnivorous	stalk-and-ambush	solitary
5.	Felidae	*Megantereon whitei*	30–100	hypercarnivorous	ambush-and-slash	solitary
6.	Felidae	*Homotherium latidens*	>100	hypercarnivorous	ambush-and-slash	pack
7.	Felidae	*Panthera gombaszoegensis*	>100	hypercarnivorous	stalk-and-ambush	solitary
8.	Felidae	*Acinonyx pardinensis*	30–100	hypercarnivorous	pursuit carnivore	solitary
9.	Felidae	*Puma pardoides*	30-100	hypercarnivorous	stalk-and-ambush	solitary
10.	Ursidae	*Ursus etruscus*	>100	hypocarnivorous	scavenger	solitary
500–300 ka (Galerian–Aurelian, Middle Pleistocene)						
11.	Mustelidae	*Gulo gulo*	10–30	carnivorous	scavenger	solitary
1.	Canidae	*C. mosbachensis-C. lupus*	10–30	carnivorous	pursuit carnivore	pack
12.	Canidae	*Cuon priscus*	10–30	hypercarnivorous	pursuit carnivore	pack
13.	Hyaenidae	*"Hyaena prisca/Parahyaena brunnea"*	30–100	bone/meat	scavenger	solitary
14.	Hyaenidae	*Crocuta crocuta*	30–100	bone/meat	pursuit carnivore	pack
4.	Felidae	*Lynx pardinus*	10–30	hypercarnivorous	stalk-and-ambush	solitary
6.	Felidae	*Homotherium latidens*	>100	hypercarnivorous	ambush-and-slash	pack
15.	Felidae	*Panthera pardus*	30–100	hypercarnivorous	stalk-and-ambush	solitary
16.	Felidae	*Panthera leo*	>100	hypercarnivorous	stalk-and-ambush	pack
17.	Ursidae	*Ursus thibetanus*	>100	hypocarnivorous	scavenger	solitary
18.	Ursidae	*Ursus arctos*	>100	hypocarnivorous	scavenger	solitary

Table 3.1: Large carnivores with their ecomorphological/behavioral parameters included in the guild structure analysis (see Figure 3.3b). Data were acquired from references cited in "3.2 Methods".

adapt (Martínez-Navarro, 2010). The extinction of *Pachycrocuta* might be additionally correlated with the disappearance of *Megantereon*, which resulted in a decrease of carrion available for scavengers. At ~600–500 ka *Panthera gombaszoegensis* and *Acinonyx pardinensis* also disappear, while the modern pantherine cats, *Panthera leo* and *Panthera pardus* occur in Europe (Fig. 3.2). The two latter species exploited carcasses more intensively than *Megantereon*, which possibly resulted in the decrease of the carrion that would be left available for both hyenas and hominins (Palmqvist et al., 2011). On the other hand, the disappearance of *Pachycrocuta* possibly offered the opportunity for larger amounts of available carrion, and for easier and early access to carcasses by hominins, who would have been most possibly outcompeted during the Early Pleistocene by the fierce giant hyena.

When we compare the Early and the Middle Pleistocene carnivore guilds (Fig. 3.3a, b, Table 3.1), we see that: 1) their structure and dynamics are different, and 2) the carnivore diversity slightly increased to 11 species during the Middle Pleistocene. It should be noted, however, that in contrast to the Early Pleistocene, the sympatry of all (or most of) these predators is not recorded so far anywhere during the Middle Pleistocene; on the contrary, the number of both predator species[4] and predator specimens in the archaeo-palaeontological sites is rather low (see also Martínez-Navarro, 2018); this is the case also for the proboscidean localities examined here, for which the predator assemblage is poor in most of them (Appendix 3.1).

In canids, the only difference involves the "replacement" of *Lycaon lycaonoides* by the slightly smaller *Cuon priscus* (still within the same BM group), but with the same diet type and hunting strategy. The number of the hypocarnivorous ursids increased with the "more omnivorous" *Ursus arctos* and the "more herbivorous" *U. thibetanus* (van Heteren, 2011; Pappa et al., 2019). There are two main changes in the Middle Pleistocene carnivore guild, compared to that of the Early Pleistocene (Fig. 3.3b): 1) the decline of taxa with a hypercarnivorous diet (the bulk of carrion providers) and an ambush hunting strategy, and 2) the increase in the number of taxa with a bone/meat diet, as well as in the representation of pack-hunting and scavenging behavior. With the disappearance of the solitary species *Megantereon whitei*, *Acinonyx pardinensis*, *Puma pardoides* (all from the middle-sized group 30–100 kg) and *Panthera gombaszoegensis*, the number of felids significantly decreased (overall from six to four), along with the demise of "ambush-and-slash" hunters. Most importantly, all these carnivores were hypercarnivorous and carcass providers (hunters), having primary access to and control of carcasses; consequently, their disappearance resulted in a decrease of available carrion for scavengers. For hominins, this change would have a dual effect: on one hand, there were less hypercarnivorous predators to compete with, and, on the other hand, less available carrion; the latter would have resulted in fewer scavenging opportunities and thereby could have offered an ecological incentive towards more regular hunting. In contrast, the number of the bone/meat eating (bone-cracking) hyenas increased to two (however, both of them were smaller than *Pachycrocuta*); as this was accompanied with the inclusion of the wolverine *Gulo gulo* and the increase of the mostly scavenging ursids (although their diet relied only little on meat), the scavenging behavior is altogether reinforced. The so far rare "*Hyaena prisca*/*Parahyaena brunnea*" (or *Pliocrocuta perrieri*; the taxonomy of this taxon is debated; see Palombo, 2014) takes over the scavenging niche previously occupied by *Pachycrocuta*. *Crocuta crocuta* employs cooperative strategies, and considering also the inclusion of *Panthera leo* (as well as of *Homo*; see below), cooperative foraging is in general reinforced during the Middle Pleistocene (see also Croitor and Brugal, 2010).

Notwithstanding the complexities surrounding the Middle Pleistocene hominin phylogeny and nomenclature (e.g., Roksandic et al., 2018), for the sake of our discussion we use *H. heidelbergensis* (*sensu lato*) as the (more or less) "representative" taxon of early-middle Middle Pleistocene hominins. When comparing body mass values in the two carnivore guilds (Fig. 3.3a), the increased BM and stature of *Homo heidelbergensis* (estimated BM of males: 70–90 kg, stature of males: 170–180 cm; Gallagher, 2013) places humans at a higher rank than that in the Early Pleistocene: besides the hypocarnivorous ursids, only *Panthera leo* and *Homotherium latidens* lie above *Homo* (Fig. 3.3a). The potential for successful confrontational scavenging, early access to and defense of carcasses against predators, would have been much higher than in the Early Pleistocene, considering also some shifts in hominin technology and subsistence strategies (including regular hunting from ~400–300 ka onwards) and an inferred increase in human social cooperation (see below). Therefore, within the carnivore guild, an overall more privileged position

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[4] Among the richest localities of this period in terms of large predators are Lunel-Viel (France) with 7 species, Taubach (Germany) with 6 species, and Arago III and Orgnac 3 (both France) with 5 species, all with human presence, and Taubach and Arago III additionally with *Palaeoloxodon* and *Mammuthus* remains, respectively.

can be assumed for hominins in the Middle as opposed to the Early Pleistocene.

Large predators (skeletal remains, carnivore bone modifications or carnivore coprolites, the latter in most cases attributable to hyenas) are present in 29 of the herein studied sites (83%), and 12 out of those (41%) preserve also carnivore modifications on proboscidean bones (34% of all the 35 sites). Moreover, 7 out of these 12 sites (58%) preserve also direct evidence (or possible direct evidence) of human exploitation (Appendix 3.1), indicating a certain degree of carnivore-human competition for early access to proboscidean carcasses, and highlighting the important interference and crucial role of carnivores in the human-proboscidean interactions. At least in two cases, humans acquired early access: at Áridos 2, where cut marks on the ventral side of a rib was attributed to evisceration (which takes place at the early stages of carcass consumption; see e.g., Blumenschine; 1986 and Potts, 1988), and at Marathousa 1, where cut and scrape marks on the ventral side of a rib are accompanied by classical peeling (fresh breakage). The vertebral column and the rib cage seem to be the proboscidean skeletal locations, which are mostly gnawed by carnivores (Appendix 3.1). Carnivore marks in the thorax region in particular are related to its opening for the consumption of intestines and inner organs, which happens at the initial feeding stages of recent and extinct lions and spotted hyenas (Haynes, 2005; Diedrich, 2014).

Recent lions (*Panthera leo*), and presumably also *Homotherium*, prey on proboscideans, but preferentially on young individuals (MacDonald, 2009; Power and Compion, 2009; van Valkenburgh et al., 2016). Considering the much larger size of *Palaeoloxodon antiquus* and *Mammuthus trogontherii* compared to recent *Loxodonta africana*, *Homotherium* would selectively target young individuals in the Middle Pleistocene. However, during this period, the Proboscidea-*Homo* record is dominated by adult proboscidean individuals (see below); it can be safely assumed that felids would have managed to kill such large adult prey only occasionally and with great difficulties, with the exception perhaps of weakened individuals. It follows that humans would not regularly acquire access to proboscidean carcasses from felid kills. Rather, they would likely take advantage of individuals already dead or caught in natural traps, in which case they would exercise either passive or active scavenging, according to the degree of carnivore interference. Alternatively, humans acquired carcasses by hunting, employing tactics such as ambush hunting, hunting with traps or confrontational encounters. However, we should note that humans take a high risk when approaching and try killing an elephant, which renders proboscidean hunting a challenging and dangerous procedure (Lewis, this volume).

In this light, we suggest the following, as a working hypothesis. In the Early Pleistocene predatory guild (Fig. 3.3b), humans would occupy the ecological space that was "available" for a predator with a 30–100 kg BM and a (mostly?) scavenging behavior, perhaps with a carnivorous or hypocarnivorous diet according to ecological circumstances and geographic setting. In the Middle Pleistocene guild, humans would occupy the niche that was previously held by the saber-toothed cat *Megantereon* (see also Werdelin and Lewis, 2013 and Egeland, 2014 for African examples) in the group of predators with 30–100 kg BM. Similar to *Megantereon*, humans could have a carnivorous to hypercarnivorous diet, but unlike the large solitary felid, the biological, technological, cultural and social developments would have allowed humans to employ not only the "ambush-and-slash" hunting strategy, for instance modified into a cooperative "ambush-and-spear" strategy (in accordance with the evidence for use of hunting spears during this period), but also a number of other hunting tactics, including for example prey stalking or prey impediment by driving animals into natural or anthropogenic traps. *The seizing of a niche previously occupied by a large felid such as Megantereon and the incorporation of such hunting behavior made humans fairly independent of erratic food sources from scavenging carnivore kills and allowed the provisioning of animal resources on a more regular basis.*

3.4.2. PROBOSCIDEAN EXPLOITATION AND HOMININ BEHAVIOR

Rather than regular hunting of proboscideans, a more opportunistic subsistence behavior of Early Pleistocene European *Homo* is suggested also by recent studies, based on estimates of carrying capacity, resource availability, the competition intensity within the carnivore guild and the network analysis of food webs (Rodríguez-Gómez et al., 2016; Lozano et al., 2016; Rodríguez and Mateos, 2018; see also Palombo and Cerilli, this volume; Rosell and Blasco, this volume). Human presence together with *Mammuthus meridionalis* is documented at a number of localities during this period, such as Dmanisi, Pirro Nord, Barranco León and Sima del Elefante (Spain). The latter sites lack so far evidence of proboscidean processing and it is not clear whether this is a real lack of human exploitation, absence of cut marks due to the thickness of periosteal connective tissue and cartilage of the bones, or a result of low archaeological resolution (e.g., due to taphonomy and preservation). Thus, on the basis of the evidence at hand, during the Early Pleistocene, the acquisition of megafauna in general, and of proboscideans in particular, appears to have been mainly occasional and sporadic. Aside from issues of differential preservation and research intensity, which undoubtedly mask our archaeological visibility, we identify two main reasons to explain the low archaeological signal for Proboscidea-*Homo* interactions in the Early Pleistocene: 1) The large carnivore guild remained stable during 1.8–0.8 Ma and all these powerful carnivores (especially *P. brevirostris*), constituted a prohibiting factor for human access to large carcasses, including proboscideans, until ~0.8 Ma, when most of them became extinct (Martínez-Navarro, 2010; Madurell-Malapeira et al., 2017). 2) The social structure of human groups, their technological means and the behavioral solutions that they employed to mitigate the risks from competition with other members of the predatory guild, were not converging towards the inclusion of proboscidean exploitation as a regular and systematic component of their subsistence strategies. Yet, one could counter-argue that an annual catch rate of "only" one or two proboscideans, such as that observed for the Mbuti hunter-gatherers [Ichikawa (this volume); of the African forest elephant *Loxodonta cyclotis*, which is much smaller than *Palaeoloxodon*; see also Lewis (this volume) and Yasuoka (this volume) for similar catch rates among the BaYaka and Baka) provides an ethnographic example of a "regular and systematic" foraging of proboscideans, and then the question is whether a comparable rate (in the Early Pleistocene) would still create a signal that is archaeologically detectable today. Factors related to the structure of the carnivore community (e.g., the ratio of flesh-eaters to carcass-destroyers, which largely determines carcass availability; Turner, 1992), habitat traits, and climatic parameters such as seasonality, would have altogether conditioned the scale to which hominins would employ any of the strategies included within their range of capabilities: from opportunistic, non-confrontational scavenging as an effective, low-risk and low-cost means of food gathering, to more active scavenging, hunting, and any combination of tactics within this spectrum of foraging options.

Whatever the means of procurement in the Early Pleistocene, carcasses were processed by use of apparently non-specialized, core-and-flake tool-kits with few retouched blanks and an overall expedient character. Nevertheless, at Barranc de la Boella, an Acheulean-like pick that was probably shaped off-site and transported to the mammoth-butchery locality, points to some degree of tool curation and foresight. Notably, at Fuente Nueva-3, one of the main aims of the debitage was the production of small flakes (flakes >30 mm are rare). The association of proboscidean carcasses with small-sized, simple flakes is observed also in the Middle Pleistocene (see below) and the evidence from Fuente Nueva-3 may be reflecting the roots of a long-lasting trend, which remains largely unexplored and unexplained. Barranc de la Boella (Pit 1 level 2) is so far the oldest locality, where possibly cut-marked proboscidean bones are reported, as well as the oldest locality with possible human modifications on proboscidean remains outside of Africa.

In the Middle Pleistocene, lithic technology associated with proboscidean carcass processing mainly involved possible heavy-duty (core-)tools, such as choppers, chopping tools and bifacial implements (including handaxes and other Large Cutting Tools), as well as flake-based retouched tools, but also minimally modified blanks (usually flakes) and cores (Appendix 3.1). However, the artifact class most commonly found together with proboscidean remains is simple, unretouched flakes of variable sizes and morphologies, together with flake fragments and debris. Use-wear and residue data show that both large(r) tools, such as bifaces or core-tools, and retouched or unretouched flakes, often of small size (<30 mm), were used in carcass processing activities such as butchering (Barkai et al., 2010; Yravedra et al., 2010; Mosquera et al., 2015; Solodenko et al., 2015; Aureli et al., 2016; Santucci et al., 2016; Lemorini, 2018; Venditti et al., 2019; Marinelli et al., this volume). Nevertheless, the traceological evidence is overall limited and obscured by preservation and excavation biases, hence it is not possible to discern inter-assemblage trends in associations between specific artifact types, typological characteristics or techno-functional traits, with distinct activities such defleshing, evisceration, filleting, skinning or disarticulation. At the moment, it is probably safe to assume that different tool types and artifact size fractions, such as bifaces and small retouched or unretouched flakes, were used in various and possibly (but not necessarily) different tasks. Use-wear data and cut marks support such a case, for instance at Áridos 2 (Yravedra et al., 2010) and Revadim (Solodenko et al., 2015; Venditti et al., 2019). This hypothesis agrees well also with results from experimental studies, which have shown that, while handaxes may be more efficient at specific tasks such as defleshing, simple or retouched flakes can be equally efficient at other tasks, such as disarticulation (Galán and Domínguez-Rodrigo, 2014; see also Jones, 1980). Moreover, both unmodified flakes and bifaces have been reported as efficient tools in proboscidean butchery experiments (e.g., Schick and Toth, 1993; Gingerich and Stanford, 2018). In carcass processing activities, simple and/or small flakes appear to entail two main advantages over bifaces: 1) they allow for better precision (e.g., Venditti et al., 2019) and 2) they yield higher return rates when raw material economics are considered, mainly because a smaller mass of raw material is needed for their production; as they also provide more cutting edge per unit of mass, tool-kits based on small-sized blanks offer economic advantages, especially to groups that are highly mobile (Galán and Domínguez-Rodrigo, 2014; Pargeter and Shea, 2019). Taphonomic biases aside, those advantages alone could partly explain the higher frequency of small flake blanks, as opposed to large(r) flakes and bifaces, at the sites included in this study, notwithstanding the broader complexities surrounding the variability in Middle Pleistocene lithic industries and questions that remain open regardless of whether we are looking at proboscidean-exploitation sites or not.

Apart from cut marks, which comprise the most straightforward proof of proboscidean meat/fat exploitation and they are present in 12 (34%) of the studied sites, breakages for brain and marrow extraction, and proboscidean bone artifacts are also regarded as direct evidence of its utilization. In Gesher Benot Ya'aqov, Notarchirico and La Cotte de St Brelade the exploitation of the brain and/or other edible parts of the head is documented. The elephant's head is of high nutritional value, and constitutes a high-quality source of protein and calories, which can be found in the brain, the tongue, the trunk and the mandible (Agam and Barkai, 2016). Bearing in mind that the head of the recent African elephant *Loxodonta africana* weighs >400 kg and an even higher weight is expected for *P. antiquus*, its full exploitation should have required from the Lower Palaeolithic humans the investment of a significant amount of time and energy (Reshef and Barkai, 2015), knowledge of its edible components, as well as social skills and constructive cooperation among the group members. Gesher Benot Ya'aqov is the oldest known locality with possible intentional breakage of a proboscidean cranium.

Intentional bone fracturing for marrow extraction is reported much later, during MIS 11, although older assemblages with proboscidean bones should be reassessed for this kind of exploitation. A recent study on *P. antiquus* limb bones from Castel di Guido, showed that, although marrow cavities are proportionally small compared to the bones' size, they do exist, and the fracturing of proboscidean bones at this site involved not only bone tool fashioning, but also consumption of marrow for nutritional purposes (Boschian et al., 2019; see also Anzidei et al., 2012: fig. 16e). Bone fracturing for marrow extraction usually takes place at a second stage of carcass exploitation, after the stripping of meat and the removal of fat, and possibly when bones are still fresh, producing thus green bone fractures (e.g., EDAR Culebro 1, PRERESA); however, the time interval between these stages is not easy to define archaeologically and would depend on the environmental conditions (for the preservation of fresh bone and of edible marrow) and on food availability (seasonality) (see also Boschian et al., 2019). Some localities evidence a third processing stage, namely the bone tool production, which experimentally has proved to be feasible on both fresh and drier bones (Stanford et al., 1981; Backwell and d'Errico, 2004); again, the time interval from the previous stage is difficult to ascertain. Taken together, brain exploitation and fracturing of bones are evident in 8 sites (23%), indicating that proboscidean carcasses were important sources not only for meat and fat.

Full exploitation of carcasses becomes evident with the manufacturing of proboscidean bone artifacts. Indeed, proboscidean bone artifacts (or possibly attributed to proboscideans) are present in 11 sites (31%) —many of which yield also bone artifacts made from other mammal bones (e.g., equids, bovids). The use of proboscidean bones as raw material for the production of cultural objects suggests that the exploitation of carcasses involved behavioral aspects beyond those related to subsistence. In lack of micro-wear investigations, we cannot discuss any possible functional use of blanks and tools made on bone fragments: depending on ecological and cultural contexts, some of them, such as percussors, scrapers or unmodified flakes, could have been produced to serve functional goals, while others were possibly manufactured for non-utilitarian purposes. Zutovski and Barkai (2016) proposed that proboscidean bone artifacts might additionally hint to cosmological, cultural and symbolic relations between proboscideans and humans. Fontana Ranuccio and Malagrotta (Italy; both MIS 13) currently represent the oldest sites with evidence of bone tools made on proboscidean bones in western Eurasia (Fig. 3.2); other younger localities include Castel di Guido, La Polledrara, Revadim, Casal de' Pazzi, and perhaps Marathousa-1, Biltzigsleben and Vértesszölös (Hungary; but see Fluck, 2011) (Appendix 3.1).

Overall, considering the limitations of preservation of human-induced modifications in proboscidean bones, as already stated in the introduction, the presence in 22 (63%) of the studied localities of direct evidence of human exploitation can be considered a relatively high number, almost double than that of direct carnivore gnawing in proboscidean bones (34%; higher also than 41%, the percentage in sites with carnivore presence; see above), indicating the significant contribution of humans in the accumulation and modification of the bones, and overall in the formation and taphonomic history of the localities.

3.4.3. REMARKS ON PROBOSCIDEAN PALAEOECOLOGY

The Middle Pleistocene Proboscidea-*Homo* records are far from being equally divided between *P. antiquus* and *Mammuthus* (in particular *M. trogontherii*, the widely distributed mammoth during the Middle Pleistocene), and there is a clear dominance of *P. antiquus* (26 sites in total[5]; 81% of the Middle

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[5] In Stanton Harcourt the mammoth accounts for more than half of the faunal assemblage and therefore the locality is included here in the *Mammuthus*-bearing sites.

Pleistocene ones with identification at genus level), as well as of localities correlated with interglacial stages (Appendix 3.1). The latter correlation can be attributed to the different ecological adaptations of these proboscideans, the environmental preferences or tolerances of hominins, as well as preservation biases. *Mammuthus trogontherii* is generally considered a steppe dweller and was a common faunal element of the glacial stages in Central Europe, adapted to open landscapes and aridity, being less abundant in the more temperate conditions of Mediterranean Europe (Athanassiou, 2012). Recent dental micro- and macrowear studies indicate grass-dominated mixed-feeding preferences (Rivals et al., 2019 and references therein). Although European sites with skeletons of *M. trogontherii* do exist during the Middle Pleistocene, there is hardly any evidence of human presence, which can be attributed to preservation biases, local extinctions of (small) human populations, lack of adequate procurement strategies, or to the less favorable habitats. On the other hand, *P. antiquus* had wide and flexible ecological adaptations, as it was an inhabitant of mild humid, warm to warm-temperate and moderately wooded to wooded environments, but also of wooded grasslands or even rather arid grasslands (Palombo et al., 2010). Palaeodietary studies indicate a dietary plasticity, which included browsing, grazing and mixed feeding (Rivals et al., 2019 and references therein). In Northern and Central Europe, it occurred during interglacial phases and apart from some exceptions, it was generally absent from the intervening cold stages of open habitats, when it was contracted to Southern Europe, which acted as a refugium (Lister, 2004). In particular, most of the Proboscidea-*Homo* localities have yielded a diversified fauna rich in medium- to large-sized herbivores, offering a wide prey spectrum for large carnivores and humans (Appendix 3.1). A lot of them include *Castor* (beaver) and *Hippopotamus*, as well as a diversity of cervids and some also the rarer primate *Macaca* (macaque), indicating the presence of permanent freshwater bodies (river or lake settings) and substantial woodland components under (at least relatively) temperate conditions. Importantly, climatic conditions in these settings would never, or only rarely, reach freezing temperatures, as indicated by the presence of beavers and hippos in the faunal lists. Thus, it seems that the environments that *P. antiquus* inhabited were also favorable settings for human occupation and subsistence (hunting/scavenging). Almost all of the sites examined here occur in fluvial or lacustrine environments; these are known to be nutritionally advantageous locations, but also depositional regimes that foster archaeological preservation.

3.4.4. EXPLORING ASPECTS OF PROBOSCIDEAN ETHOLOGY AS INTERPRETATIVE TOOLS

Mammuthus meridionalis, *M. trogontherii* and *P. antiquus* with mean BMs >9 tones (Larramendi, 2016) were by far the largest terrestrial animals of the Pleistocene terrestrial ecosystems of Europe, clearly surpassing other megaherbivores, such as *Hippopotamus* and the rhino *Stephanorhinus*. However, direct evidence (in the form of cut marks) for the exploitation of these latter taxa in Europe is so far limited (Appendix 3.2), while although 22 (63%) of the studied proboscidean localities yielded also hippos and/or rhinos, only 2 of them (9%) preserve also cut marks on these megaherbivores. Moreover, in contrast to the 12 localities bearing cut marks on proboscidean bones, cut marks in hippo bones exist so far only in 4 localities and in rhino bones in 8 (including both open-air and cave ones). For *H. antiquus* this could be possibly attributed to its strongly aquatic life habits going usually only sporadically outside of water bodies and feeding mainly on aquatic vegetation (Palmqvist et al., 2003; Martínez-Navarro, 2010). Even if we consider an occasional nocturnal feeding activity on land, like the recent *H. amphibius*, its tracking down and hunting in the dark would be particularly difficult and challenging for humans, especially considering that *H. amphibius* is a dangerous animal, responsible for numerous human deaths annually (Eltringham in Hutchins et al., 2004). Similarly, rhinos show aggressive behavior and can be frightening animals to encounter, often chasing human intruders (especially the black rhino *Diceros bicornis*); rhinos have also an acute sense of smell, detecting human scent even at a distance of ~800 m, alarming them to ran away (Owen-Smith in Hutchins et al., 2004).

In contrast to the scanty evidence for hippo and rhino exploitation, the proboscidean exploitation record is rather abundant (Appendix 3.1), even though the enormous size of elephants and the fact that they live in flocks constituted probably a prohibiting factor for the direct confrontation and hunting by both large carnivores and humans. Firstly, it seems possible that human exploitation involved individuals that were already killed by other predators or died by natural causes, or individuals that were vulnerable and/or weakened by e.g., diseases, injuries or malnutrition; the latter would usually stay close to water sources, abandoned from their flock (Cannell, 2014). Secondly, certain aspects in the behavior of proboscideans and the way they modify the landscape would have served to the advantage of human foraging tactics (Haynes, 2006, 2012). For example, elephants repeatedly use known paths leading to water sources; this habit would have allowed hominins to practice particular hunting strategies, including the use of natural traps, ambushes, use of spears and inflicting injuries, especially on their vulnerable cushioned feet (Haynes, 2006, 2012; Cannell, 2014; Agam and Barkai, 2018; Lewis, this volume). Thirdly, male individuals acquire a more solitary life after puberty (see below), which makes them more vulnerable and perhaps an easier target, while specifically during the musth period (when testosterone levels are increased) combats between males (accompanied by loud vocalizations and thus easy to be located by humans) can potentially end with the death of one of the individuals (Lister in Hutchins et al., 2004). Lastly, elephants are not territorial, they do not defend their range, which overlaps with that of other animals, and they are not aggressive except when males are in musth (Lister in Hutchins et al., 2004).

In light of the above, there are two additionally interesting outcomes from the assessment of the Proboscidea-*Homo* open-air Early–Middle Pleistocene localities in western Eurasia: 1) males prevail in the record, and 2) most of the sites involve subadult/adult proboscidean individuals[6] (Appendix 3.1), corresponding to the Type C ("selective mortality") of Haynes (2017). Despite the fact that adult males had markedly more robust body size and more powerful tusks compared to females and juveniles, and thus were more deterring, there are some possible explanations of their higher percentage in butchering sites, related mainly to the elephants' social organization: 1) The fact that elephants live in flocks is a prohibiting factor for predators (both carnivores and humans), which would have to face the protection and defensive behavior of adults (MacDonald, 2009). Indeed, young elephants stay closely dependent on their mother in the first ten years, being additionally protected by the whole female-dominant group (MacDonald, 2009). 2) In contrast to females, males on puberty leave or are forced out of the family; fully-grown adult males acquire a more nomadic and solitary life, roaming either alone or in loose groupings (Moss, 1988; Lister in Hutchins et al., 2004; MacDonald, 2009). Consequently, it becomes more possible for males to enter an unfamiliar landscape, get into more difficult or dangerous situations and take higher risks when roaming a more adventurous terrain, increasing also the proneness to be caught, injured or die in natural traps (Moss, 1988; see also Lister and Agenbroad, 1994; Álvarez-Lao et al., 2009; Haynes, 2017; Pečnerová et al., 2017 for mammoth analogies). Studies on extant African elephants show that particularly during dry seasons, adult males frequent more types of habitats than

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[6] When the approximate ontogenetic age is known, we infer that these individuals did not die due to advanced age, considering that *P. antiquus* lifespan was ~75 years.

family units do, which stay closer to permanent water spots; and that bulls roam widely away from drinking water sources in order to exploit scattered feeding "hotspots" and avoid conflict with bulls in musth (Stokke and du Toit, 2002; see also below). 3) Another reason is based on the frequency of injuries. Observations on African elephants show that injuries (67% human-caused) are by far more common (84.3%) in adult individuals (older than 8 years according to the study) than juveniles, and that males are the dominant sex injured (84%), indicating that adult males are the most susceptible group (Obanda et al., 2008). Moreover, during the musth period, starting on average at ~29 years old, male elephants present highly aggressive behavior towards other males. During this periodic condition, agonistic interactions are more intense, involving threat displays, chasing and minor combat using tusks, possibly causing injuries, while these fights can even result in the death of one of the males (MacDonald, 2009). Under all the above more venturous circumstances, the vulnerability potential of the male individual is increased. Particularly in the case of natural traps, apart from the higher preservation ratio (Pečnerová et al., 2017), it would be also easier for early humans to take advantage of trapped, weakened, injured or even dead individuals. Skeletons of subadult/adult male individuals dominate also in the non-anthropogenic record of Middle Pleistocene open-air localities, which further supports the observation that adult males are more prone to die from predation, injuries from intra-specific combats and other causes (e.g., natural traps) not related to senility (e.g., Lister, 1996; Lister and Stuart, 2010; Tsoukala et al., 2011; Athanassiou, 2012; Lister et al., 2012; Kevrekidis and Mol, 2016; Titov and Golovachev, 2017). Late Middle Palaeolithic hominins were practicing both selective (i.e., targeting prime adults; see e.g., Gaudzinski and Roebroeks, 2000) and non-selective (e.g., Marín et al., 2017) large mammal hunting strategies. The aforementioned adult-biased pattern in our proboscidean dataset may be foreshadowing a similar situation, indirectly reflecting the process of hominin establishment in the hunting niche.

3.5 CONCLUSIONS

It is relatively shortly after the first "out of Africa" dispersal and contemporaneously with the first appearance of humans in Europe, at ~1.3–1.2 Ma, when the first possible Proboscidea-*Homo* event is attested (Fuente Nueva-3). During the Early Pleistocene and the early part of the Middle Pleistocene, sites with evidence of proboscidean (and, generally, megafauna) exploitation are geographically confined to southern, temperate regions. Proboscidean exploitation likely involved individuals that died naturally, caught in natural traps, injured or died because of combat with conspecifics; alternatively, it involved juveniles, adult female and young adult male individuals that were injured and/or killed by formidable predators, with the saber-toothed cat *Homotherium* probably being the most capable attacker. However, access to these carcasses by humans, especially in the presence of the largest ever hyena *Pachycrocuta brevirostris*, would have been particularly challenging, if not usually impossible. Considering the scantiness of the evidence (Fig. 3.2, Appendix 3.1), proboscidean exploitation during the Early Pleistocene seems to have been only occasional and sporadic; carcass acquisition possibly relied on passive and —perhaps more possibly— active scavenging, and carcasses were processed with expedient lithic tool-kits. Proboscidean hunting cannot be excluded, but, along with the arguments presented here, e.g., with regard to carnivore guild dynamics, the archaeological evidence does not support the case for regular, systematic hunting in the Early Pleistocene, although we acknowledge the pitfalls of such an inferential, qualitative assessment: future studies should address the issue of how many proboscideans should a group hunt in order to "qualify" for hunting that is "regular and systematic" enough to leave a traceable signal in the archaeological record or the isotopic data and/or also be comparable with ethnographic accounts.

Between ~900 ka and ~600–500 ka (late Early and early Middle Pleistocene), there is a general scarcity of Palaeolithic sites in Europe and a gap (absence of human presence) is observed at sites with long sequences (e.g., Atapuerca). Therefore, the scarcity of proboscidean-processing sites in this time-block likely reflects a broader picture of a scattered, low-density and discontinuous human presence. Similarly, the remarkable increase of sites with proboscidean exploitation after ~500 ka onwards is certainly related to an overall increase of archaeological sites in western Eurasia, signaling a more continuous hominin occupation.

The more extensive utilization of proboscidean carcasses in the Middle Pleistocene is supported by direct evidence, such as cut marks, breakages for brain and marrow extraction, bone artifacts and impact flakes, as well as by early access to carcasses and transport of bones to occupational locations (Fig. 3.2, Appendix 3.1). Overall, there exist indications for some sort of "niche incursion" by humans as highly carnivorous omnivores, acquiring a higher rank within the predator guild. The firm archaeological signal for proboscidean and other megafauna exploitation (Fig. 3.2, Appendices 3.1, 3.2) indicates that megafauna procurement and carcass processing was "more-than-a-marginal" strategy (Yravedra et al., 2010) and included not only scavenging but also hunting; in either case, the main targets appear to have been subadult/adult males, which were roaming solitary in the landscape.

Unsurprisingly, there is no specific reduction method, type of tool-kit, or techno-complex associated with proboscidean exploitation sites. In various combinations, bifaces co-occur with core-tools of "Mode 1" morphologies as well as with small-sized tools and simple flakes, diachronically (see e.g., the Italian sites), synchronically, and even within the same lithic assemblage (e.g., Notarchirico). As a broad-brush pattern, we are dealing with usually small lithic assemblages, characterized by an *ad hoc* production of mostly flake blanks made on local raw materials. However, a more or less expedient character is not mutually exclusive to the presence of curated and imported tools, as well as to the evidence for on-site tool maintenance, which can be seen as structural elements in the technical systems, in turn suggesting planned activities. A fuller exploitation of proboscidean carcasses, i.e., including bone fracturing for marrow and the manufacturing of bone implements, chronologically matches the main spread of the Acheulean after ~600–500 ka, but it remains unclear exactly how developments in lithic technology influenced the ways and the extent to which proboscidean carcasses were being exploited. Reporting on an elephant-butchery experiment, Gingerich and Stanford (2018: p. 272) note that "hafting style was the most important determinant of a tool's functionality" and that "efficiency and preference for a particular tool was based more on the haft than any other factor". The hafting of stone-tools on shafts would have increased leverage and efficiency in certain processing tasks, but, besides Cava Campitello (Italy; ~200 ka) there is hardly any evidence for hafting before MIS 7 in general and at the sites examined here in particular (but see Alperson-Afil and Goren-Inbar, 2016). After ~200 ka, we see the appearance of more complex technological procedures, such as hafting, and more curated, "mobile industries" (e.g., Levallois), which increase core productivity and allow for the production of standardized blanks with multiple cutting edges. However, the ways in which such shifts in lithic technical systems influenced (viz. improved) proboscidean *procurement strategies* (e.g., hunting) and/or *processing* activities, remain largely unexplored. Wooden implements, which are essentially invisible in the record, would have almost certainly been utilized for both procurement and processing tasks; it is of note that some (if not all) of the most important wooden artifacts ever found, have been recovered from sites where megafaunal remains (including proboscideans) are also present: Clacton-on-Sea, Schöningen, Lehringen and Poggetti Vecchi. It appears that *from ~600–500 ka and perhaps especially after ~200 ka onwards, hominins had* *resolved most of the behavioral or logistical limitations associated with rendering proboscidean exploitation an ecologically viable, nutritionally gainful, socially beneficial and energetically efficient component of their subsistence strategies*. This change is chronologically correlated and largely associated causally with the following parameters and processes:

1. The disappearance of most of the late Villafranchian–Epivillafranchian (Early Pleistocene) components of the large carnivore guild, which was dominated by large-sized, hypercarnivorous and mostly ambush-hunting felids, and by the large-sized, bone-cracking (possibly pack-hunting) scavenger *Pachycrocuta*. These taxa were replaced during the Middle Pleistocene by the Galerian to modern hyenas and felids (Fig. 3.2); as a whole, the large carnivore guild is marked by a decrease in carrion providers, and by a higher representation of species with scavenging, bone-cracking and pack-hunting behavior. Moreover, even though the carnivore diversity slightly increased during this period, carnivore representation in the archaeo-palaeontological localities is rather low in both species and specimens number. Decline of large carnivore representation is possibly an anthropogenic effect on the ecosystem: first, due to the firmer establishment of the hominin niche, including anti-predator strategies and expulsion of large carnivores from the region of human influence; and second, due to the reduction of food quantity through human confrontational scavenging or decrease in prey availability through human hunting (see also Lewis and Werdelin, 2007; Faurby et al., 2020). This effect was probably initiated in the Early Pleistocene, but it is essentially in the Middle Pleistocene, when humans appear to successfully outcompete large carnivores.
2. Human brain size and body size/mass increased to modern levels, with implications that include cognitive developments and behavioral plasticity (e.g., Galway-Witham et al., 2019 and references therein).
3. A more continuous occupation of Europe is observed, which is probably related to a demographic growth and included also the peopling of higher latitudes (Roebroeks, 2001). This is reflected in the appearance of Proboscidea-*Homo* localities in the more continental climates of central and northern Europe (Figs. 3.1, 3.2; see also Wenban-Smith, this volume).
4. A number of other biocultural changes can be inferred from the hominin fossil and archaeological record. Some of the most important include: a potential increase in group sizes; (expansion of) cooperative breeding and foraging, possibly accompanied with more regular food sharing practices; habitual use of fire and possible emergence of pyrotechnology; and the standardizing of hunting as foraging strategy. An overall increase in foraging efficacy is thereby inferred, and there is some consensus that, under favorable social and ecological conditions, cooperative hunting was well-embedded in the suite of hominin subsistence strategies already from ~500–400 ka.

In sum, alongside the changes in large carnivore dynamics, rather than technological developments *per se* (spread of the “biface phenomenon” a.k.a. the Acheulean, and prepared-core techniques, e.g., Levallois), it was biologically, socially and culturally negotiated behaviors that enabled or encouraged in the middle–late Middle Pleistocene the exploitation of proboscideans, to an extent that was broader and probably more systematic than that of the preceding periods but still conditioned by a presumably narrow range of ecological and social circumstances. Consequently, even if it can be inferred that middle–late Middle Pleistocene hominins hunted proboscideans more regularly and successfully than in preceding periods, this does not necessarily mean that proboscidean hunting became a fixed and omnipresent subsistence behavior from a particular point in time onwards. In our interpretation of the data, and following the argumentation of Byers and Ugan (2005), there is no strong evidence for hominin specialization in proboscidean exploitation, at least not in the sense of exploiting proboscideans preferentially over other smaller-sized taxa, or in the sense of a very specific hunting target, as in the case of Neanderthal hunting of certain middle-sized ungulates (e.g., monospecific hunting of bovids, cervids or equids; see e.g., Gaudzinski and Roebroeks, 2000; Dusseldorp, 2012, 2013 and references therein).

Several behavioral aspects, such as strategic hunting using relief, decoys or wooden traps, are hardly detectable (if at all) in the material culture or on the fossil remains, and the challenge is to develop analytical tools that will address their role and provide nuanced interpretative frameworks. Along with research on hominin social systems, observations from proboscidean ethology and ethnographical accounts need to be more extensively incorporated, not only in large-scale studies, but also in the interpretations of individual sites. Finally, the proboscidean *versus* hominin palaeoecology, and in particular their position and role in trophic dynamics, as well as home range expansions and contractions, also require further investigation.

Proboscidean procurement and processing must have posed significant, and in many ways unique, challenges to hominins; in that sense, the trajectory and possible evolutionary implications of proboscidean exploitation offers valuable insights to human evolution. Elephants are nowadays among the animals known to use tools, and they exhibit mirror self-recognition, which indicates some degree of self-awareness and a high level of cognition. They are also well-known for mourning their dead and for having strong individual personalities, high intelligence and memory skills, a complex social organization and large social networks (MacDonald, 2009). Provided that some of these properties can be projected to the Pleistocene taxa, proboscideans were to hominins more than a source of food (Speth, 2010; Barkai, 2019). Exploring the non-nutritional, non-functional aspects of hominin-proboscidean interactions is a major challenge for future research.

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	Locality	Age (ka)	MIS	Setting	Taxon	MNI	Gender	Ontogenetic age
1.	Fuente Nueva-3, ULS III (c. III.1)	~1300		fluvio-lacustrine	*M. meridionalis*	1	female	adult (60)
2.	Barranc de la Boella, Pit 1, level 2	960–780		fluvio-deltaic	*M. meridionalis*	2		1 adult (30), 1 juvenile
3.	Gesher Benot Ya'aqov, Layer II-6 L1	780	19	lacustrine	*P. antiquus*	1	female?	at least subadult
4.	Notarchirico, levels A-A1-B	670–610	16	fluvial	*P. antiquus*	1	male	subadult
5.	Ficoncella	~500	13	fluvial	*P. antiquus*	1	male	adult
6.	Malagrotta	~516	13		*P. antiquus*			
7.	Bełchatów	~500		fluvial	*M. trogontherii*	1		
8.	Marathousa 1	~500–400	12/11	lacustrine	*P. antiquus*	2	male	adult (~60)
9.	Ebbsfleet, Phase 6	~425–375	11	lacustrine	*P. antiquus*	1	male	adult (43–49)
10.	Castel di Guido	412	11	fluvio-lacustrine	*P. antiquus*	11		10 adults, 1 juvenile
11.	Fontana Ranuccio	~400	11	fluvio-lacustrine	*P. antiquus*			
12.	Kärlich-Seeufer	396±20	11	lacustrine	*P. antiquus*	8		juvenile to adult (subadults/adults prevail)
13.	Aridos 1	380±45	11	fluvial	*P. antiquus*	1	female	adult
14.	Aridos 2	~380	11	fluvial	*P. antiquus*	1	male	adult
15.	Ambrona, AS3	>350	11	fluvio-lacustrine	*P. antiquus*	3	male	adult
16.	Terra Amata (all levels)		11	coastal	*P. antiquus*	13		juvenile to adult (juveniles prevail)
17.	La Polledrara	325	9	fluvio-palustrine	*P. antiquus*	>25	males prevail	adults prevail
18.	Schöningen	~300	9	lacustrine	*P. antiquus*	>10		
19.	Biltzigsleben		11 or 9 or 7	fluvial	*P. antiquus*			
20.	Revadim Quarry	500–300		fluvial	*P. antiquus*	6		
21.	Ranville	230–205	7	karstic (secondary)	*P. antiquus*	1		subadult
22.	Torralba	~200	7	fluvial	*P. antiquus*			
23.	Stanton Harcourt	~200	7	fluvial	*M. trogontherii*?, *P. antiquus*			
24.	Casal de' Pazzi	270–250	7	fluvial	*P. antiquus*			
25.	Poggetti Vecchi	~171	7/6	lacustrine	*P. antiquus*	7	female and male	juvenile (1–8), subadults-adults (14–>40)
26.	Ariendorf 2		8 or 6	aeolian loess	*Mammuthus sp.*	2		subadult (15–18)
27.	Cava Campitello	206–201?	7?	fluvial	*P. antiquus*	1	female	subadult (18–20)
28.	La Cotte de St Brelade, Layers 3 & 6.1		6	fissure	*M. primigenius*	7/11 (3/6.1)		adult
29.	PRERESA	270–169	6	fluvial	Elephantidae indet.	1		
30.	Bollschweil	198–131	6	loess	*M. primigenius*	6		juvenile to adult
31.	Arriaga IIa		6–5	fluvial	*P. antiquus*	1	female	adult
32.	Neumark Nord 1	~120	5e	lacustrine	*P. antiquus*	~70	males prevail	adults prevail
33.	EDAR Culebro 1	~120	5e	fluvial	*Mammuthus* sp.	1	male	subadult
34.	Lehringen	~120	5e	lacustrine	*P. antiquus*	1		adult (45)
35.	Gröbern	~120	5e	lacustrine	*P. antiquus*	1	male	adult (35–40)

	Skeletal elements (Elephantidae)	Direct evidence	Cut-marked element	Cutmark purpose	Indirect evidence
1.	1 partial skeleton				LA
2.	1 partial skeleton, 1 neonatal tooth	CM	ribs	defleshing	LA, RF, UWA
3.	cranium, tusk, molar fragments	BE			LA, WA
4.	1 partial skeleton	BE?, HF? (long bone)			LA, HR
5.	1 partial skeleton				LA, RF, UWA
6.	bone fragments, molar	PBA			LA, BA
7.	rib	CM	rib	filleting	
8.	1 partial skeleton and other bones/teeth	CM, PBA	tibia and astragalus (skeleton), rib	disarticulation, defleshing, peeling	LA, BA, RF
9.	1 partial skeleton				LA, RF
10.	1 partial skeleton and other elements	CM, HF, PBA	ribs and long bone diaphyses		LA, BA
11.	several elements	PBA			LA, HR, BA
12.	several bones/teeth				LA, RF
13.	1 partial skeleton				LA, RF, UWA
14.	1 partial skeleton	CM	ribs, scapula	evisceration (ribs), filleting (scapula)	LA, UWA
15.	1 partial skeleton and other elements	CM, HF (femur)	cranium (premaxilla)		LA
16.	500 elements				LA, BA
17.	3 partial skeletons and other bones/teeth	HF, PBA			LA, RF, UWA, BA, HR
18.	1 partial skeleton and other bones/teeth	PBA?			LA, BA, UWA, WA
19.	several bones	CM, PBA			LA, HR, BA
20.	155 bones and teeth	CM, PBA	ribs, scapula	filleting	LA, BA
21.	1 partial skeleton				LA
22.	several bones	CM, PBA	fragment		LA
23.	several bones/teeth				LA
24.	tusks/bones	PBA			LA
25.	292 bones and teeth	PBA			LA, WA, BA
26.	several bones/teeth				LA, RF
27.	1 partial skeleton				LA
28.	241 (Layer 3) and 168 (Layer 6.1) elements	CM, BE	including scapula, femur		LA
29.	1 partial skeleton	CM, HF	6 diaphyses fragments		LA, RF
30.	229 bones and teeth				LA
31.	1 partial skeleton	CM?	rib		LA
32.	>1500 elements, several partial skeletons				LA
33.	1 partial skeleton	HF (humerus)			LA
34.	1 partial skeleton	WW			LA, RF
35.	1 partial skeleton				LA, UWA

	Large carnivores	Carnivore gnawing (on elephant bones)	Carnivore coprolites	Other large mammals
1.	*Lynx* cf. *pardinus, Pachycrocuta brevirostris, Canis mosbachensis, Lycaon lycaonoides, Ursus etruscus*		yes (*Pachycrocuta*)	Can, Mu, Rh, Eq, Hi, Bo, Ce
2.	+ (tooth marks from a medium-large carnivore on a cervid's antler)			Ce, Eq
3.	+ (carnivore modifications on 2 mammal bones)			Can, Hi, Ce, Bo
4.				Su, Ce, Bo
5.	Hyanidae indet.? (based on coprolite)	vertebrae, pelvis	yes (*Crocuta*?)	Eq, ?Hi, Ce, Bo
6.	*Canis* sp.			Eq, Rh, Su, Hi, Ce, Bo, Cas
7.				Ce
8.	*Canis* sp.	vertebra, not of the skeleton		Cer, Fe, Can, Mu, Hi, Ce, Bo, Cas
9.				Mu, Rh, Su, Ce, Bo, Cas
10.	*Panthera leo*, *Canis lupus*			Eq, Rh, Su, Hi, Ce, Bo
11.	*Panthera leo*, *Crocuta crocuta*, *Canis mosbachensis*, *Ursus deningeri*			Cer, Eq, Rh, Su, Hi, Ce, Bo, Cas
12.	*Panthera leo*, Hyaenidae indet. (based on tooth marks)	vertebrae		Eq, Su, Ce, Bo
13.	Canidae indet.			Su, Hi, Ce, Bo, Cas
14.	Hyaenidae indet. (based on tooth marks)	humerus		
15.	*Panthera leo*			Eq, Ce, Bo
16.	*Ursus arctos*			Rh, Su, Ce, Bo
17.	*Canis lupus*			Cer, Can, Eq, Rh, Su, Ce, Bo
18.	*Homotherium latidens*, *Panthera leo*?, *Canis lupus*, *Ursus thibetanus*, *Ursus deningeri-spelaeus*	yes		Can, Mus, Eq, Rh, Su, Ce, Bo, Cas
19.	*Panthera leo*, *Crocuta crocuta*, *Canis lupus*, *Ursus deningeri-spelaeus*			Cer, Fe, Can, Mu, Eq, Rh, Su, Ce, Bo, Cas
20.	Hyaenidae indet.	rib, pelvis, mandible		Fe, Eq, Su, Ce, Bo
21.	*Canis lupus*			Can, Eq, Rh, Ce, Bo
22.	+ (carnivore modifications on several mammal bones)	rib, phalanx		Eq, Rh, Hi, Bo, Ce
23.	*Panthera leo*, *Ursus arctos*, Canidae indet., Hyaenidae indet.			Eq, Bo, Ce
24.	*Crocuta crocuta*, *Canis lupus*			Eq, Rh, Su, Hi, Ce, Bo
25.	*Crocuta crocuta*, *Ursus deningeri-spelaeus*	juvenile mandible, vertebrae, rib, ulna, humerus, femur	yes	Ce, Bo
26.	*Canis lupus*	ribs		Eq, Rh, Ce, Bo
27.				
28.	*Canis lupus*, *Ursus* sp.	yes		Can, Eq, Rh, Ce, Bo
29.	*Lynx pardinus*, *Canis lupus*			Can, Mu, Eq, Ce, Bo
30.	*Ursus* sp.			Eq, Rh, Ce, Bo
31.				Eq, Rh, Ce, Bo
32.	*Panthera leo*, *Crocuta crocuta*, *Canis lupus*, *Ursus spelaeus*	vertebrae, ribs, several limb bones	yes (*Crocuta*)	Can, Mu, Rh, Ce, Bo
33.				Eq, Ce
34.	*Canis lupus*, *Ursus* cf. *arctos*			Fe, Eq, Rh, Ce, Bo, Cas
35.	+	yes		Rh, Ce

	Number of lithics	**Techno-complex/Cultural period**	**Lithic raw materials**
1.	17	core-and-flake	limestone; flint; local procurement
2.	125	core-and-flake; 1 LCT	chert; schist; quartz; sandstone; granite; quartzite; local procurement
3.	62935 (2228 >20mm)	Acheulean (Large-Flake-Acheulian)	flint; basalt; limestone; probably local procurement
4.	42	core-and-flake & Acheulean	limestone; flint; quartzite; local procurement
5.	409 (129 >5mm)	„small-tool" production	flint; chalcedony; quartz; limestone; probably local rocurement
6.	601	core-and-flake (incl. pebble-tools)	limestone; flint
7.			
8.	1876 (390 >15mm)	core-and-flake; „small-tool" production	radiolarite; flint; limestone; quartz; local procurement
9.	77 (65 >20mm)	core-and-flake („Clactonian")	flint; local procurement
10.	292	Acheulean; pebble-tools & small flake-tools	flint; limestone; lava; calcareous silt; sandstone; quartz; pumice
11.	>150	5 LCTs & „small-tool" production	flint; lava; limestone
12.	146	core-and-flake & Acheulean	quartzite; quartz; siliceous slate; chert
13.	331	Acheulean	flint; quartzite; local procurement
14.	34	Acheulean	flint; chert; quartzite; local
15.	72	Acheulean	flint; limestone; quartzite; quartz; local & distant procurement
16.	>68000	Acheulean	flint; limestone
17.	~600	„small-tool" production	limestone; flint
18.	~2000	core-and-flake	flint
19.		„small-tool" production	flint; chert; local procurement
20.	984 (Locality 21); „few" (Locality 31)	Acheulean	flint
21.	>300	early Middle Palaeolithic	flint, sandstone, quartz; local procurement
22.	887	Acheulean	flint; quartzite; quartz; limestone
23.	9	n/d	flint, quaartzite
24.	~1700	Acheulean	flint; limestone
25.	Unit 2: 827	early Middle Palaeolithic	chert; radiolarite; quartzite; local procurement
26.	37	early Middle Palaeolithic	quartz; quartzite; silicious slate
27.	3	n/d	flint
28.	1185 (Layer 3); 95 (Layer 6.1)	Middle Palaeolithic	flint
29.	754	n/d	flint; quartz
30.	12	n/d (Middle or Lower Palaeolithic?)	chert, quartz, quartzite, amphibolite, siliceous slate
31.	43	Acheulean/early Middle Palaeolithic?	flint; local procurement
32.		Middle Palaeolithic	flint; local procurement
33.	243	n/d	flint; local procurement
34.	27	Middle Palaeolithic	flint
35.	26	Middle Palaeolithic	flint

	Notes on lithic assemblage
1.	uni-, bi- or poly-facially reduced; bipolar; flakes >30mm rare; aim of debitage: production of small flakes
2.	simple flakes; few retouched tools; 1 LCT: pick; 3 hammerstones, 7 cobbles as percussors, 3 cores
3.	several red. methods, incl. Levallois, discoidal, cores-on-flakes; high freq. of small retouched tools on flint
4.	freehand & bipolar; diversified but poorly standardized artifacts; bifaces; pebbles; core-and-flake tools
5.	2 different reduction sequences for flint & limestone; high number of retouch & confection flakes
6.	multi- and bi-directional cores; 1 handaxe?
7.	
8.	freehand & bipolar, expedient knapping; tool manufacture, use, maintenance; diverse tool-kit; backing
9.	ad hoc reduction; multi- and alternate platform cores; flake-tools; on-site knapping
10.	mono- and bi-facial core-tools; few flake-tools
11.	high number of retouched tools (mostly scrapers); bifaces, cores, choppers, small flakes
12.	cores: uni- and bi-facial, 1 bipolar; very few retouched pieces; bifaces
13.	Levallois cores & flakes; 2 biface tip-resharpening flakes; on-site knapping of 16 cores and 3 choppers
14.	quartzite biface & cleaver maybe imported
15.	small-tools on flakes; 2 bifaces
16.	bifaces; choppers/chopping tools; diverse toolkit; „complete" reduction sequences
17.	cores on pebbles & flakes: unidirectional, centripetal; bipolar; core-tools, fragmented & atypical retouched tools, composite tools frequent
18.	imported tools & retouching; unstandardized flakes; opportunistic use of natural spalls as blanks; hard+soft hammer; no cores
19.	cores: unifacial, uni-&bi-directional, alternate flaking, „discoidal"; backed & pointed tools, notches, bifacially-retouched points
20.	LCTs together with small-sized tools; 1-, 2 or multi-platform cores, „prepared" cores with hierarchical surfaces; flaked-flakes (recycled)
21.	ad hoc working of imported cores (1 Levallois); handaxe reduction and subsequent export
22.	discoidal cores
23.	5 handaxes, 1 core-on-flake; rolled, weathered; artifacts may be non-contamporaneous
24.	scrapers, notches, denticulates, core-tools, 1 handaxe
25.	cores on flakes & pebbles, unidirectional; scrapers, notches, choppers; on-site retouching; low standardization; no prepared cores
26.	unmodified flakes, cores, core frag.; no prepared cores
27.	unretouched flakes with adhesives indicating hafting; centripetal flaking
28.	Layer 3: small discoidal cores, little Levallois flaking; on-site tool resharpening and recycling
29.	mostly unretouched flakes; tools: retouched flakes, denticulates, composite tools
30.	1 handaxe
31.	cores; bifaces; choppers; flakes; scrapers
32.	prepared cores (incl. discoidal, Levallois), flaked-flakes; elongated flake-tools, notches, denticulates, pointed, scrapers
33.	cores: discoidal, bifacial, polyhedric; high percentage of knapping debris and simple flakes (incl. resharpening flakes)
34.	refits; flakes produced from prepared cores
35.	lithics not produced on the spot; mostly large unretouched flakes, probably from prepared cores (discoid?)

	Bone artifacts	**Interpretation**
1.		competion between humans and hyenas for mammoth exploitation
2.		butchering event of a mammoth carcass
3.		butchery site; inversion of the cranium and deliberate breakage for brain extraction
4.		butchering event including possible utilization of soft parts of the cranium; association between lithic artefacts and bones not clearly demonstrated
5.		the carcass was possibly partially trapped in floodplain sediments; alternating human and carnivores exploitation
6.	mainly on megafauna; 1 biface, 4 scrapers, 1 end-scraper	lithic (and faunal?) material most likely in secondary context (fluvial): causal association between lithics and fossils is equivocal
7.		secondary context, fluvial bone transport
8.	flakes, flake-tools, mimicking lithics (size, form); percussor	knapping events in the vicinity of a lake shore and exploitation of large mammals including elephants
9.		on-the-spot manufacture of stone tools to butcher the elephant
10.	on diaphyses of bovids, equids, elephants; total N=366–372: bifaces (99), specimens with wear traces (142), various flake-tools & scrapers (125)	complex palimpsest with natural transport of bones, frequent human activities for exploitation of meat, marrow and tool production
11.	mainly on elephant bones, but also horse, bovid, deer; great variety in form, shape and size of bone tools, incl. handaxes	
12.		complex site formation processes; palimpsest involving human activities in the vicinity of a lake
13.		exploitation of elephant carcass
14.		exploitation of elephant carcass
15.		natural deposition with regular exploitation by humans
16.	retoucher	short-term visits and more sustained human occupation; red deer hunting and carcasses transportation, young elephants transported (hunted?)
17.	minimum 8: scrapers, denticulates, specimens with uni- & bifacial flaking	elephants were trapped in muddy sediments and exploited by humans
18.	~100: retouchers, percussors, anvils, used/smoothened-tip tools	hunting and local exploitation of a wide range of herbivores, most notably horses; carnivore modifications also present
19.	minimum 1 handaxe; minimally to heavily flaked specimens	association of fauna and lithics most likely fortuitous due to reworking by various site formation processes
20.	elephant bones: a wedge-like tool with smoothed edge; tools shaped on flakes, possible bifacial flaking	exploitation of elephant carcass(es?) (Loc. 21, 31?); causal association with anthropogenic material unconfirmed (e.g., Loc. 2, 3, 30, 25?, 31?)
21.		exploitation of elephant carcass, whose meat-bearing elements are missing and transported elsewhere; collapse of the primary context into the karstic fissure
22.	2 bifacially flaked elephant bones	alternating of human activity and natural events
23.		secondary, fluvial context: no causal association of artifacts and fauna
24.	1 specimen with truncated end & unidirectional scars	possibly natural accumulation with no causal association between lithics and fauna
25.	~15 flakes; retouched fragments; specimens with signs of abrasion	the elephants died by a natural cause and were butchered soon after their death
26.		humans killed a weakened animal or exploited an already died individual
27.		elephant exploitation cannot be demonstrated
28.		long-term Neanderthal occupation site used strategically, commanding a hunting locale, periodically being abandoned; original game drive locality/kill-site interpretation questioned
29.		exploitation of proboscidean carcass for meat and marrow
30.		humans contributed to the faunal accumulation, but not definitive causal assocciation between lithic artifacts and fauna (reworked sediments)
31.		possible human exploitation of the carcass
32.		several partly articulated skeletons of a wide range of animals, occasionally associated with lithic artefacts; carnivore and human exploitation of herbivores
33.		exploitation of a mammoth carcass including acquisition of bone marrow
34.		hunting and butchery site
35.		humans either killed an already weakened by disease individual or took advantage of an already deceased individual

Appendix 3.1: Summary table with all studied Proboscidea-*Homo* localities of western Eurasia and the examined parameters.

Direct and indirect evidence: BA, (non-proboscidean) bone artifact; BE, brain extraction; CM cut marks; HF, human-made fracture; HR, human remains; LA, lithic artifacts; PBA, proboscidean bone artifact; RF, refitting of lithic artifacts; UWA, use-wear analysis; WA, wooden artifacts; WW, wooden weapons.

Fauna: Bo, Bovidae; Can, Canidae (*Vulpes*); Ce, Cervidae, Cer, Cercopithecidae (*Macaca*); Eq, Equidae; Fe, Felidae (*Felis*); Hi, Hippopotamidae; Mu, Mustelidae (except of *Gulo*); Rh, Rhinocerotidae; Su, Suidae; megafauna is marked with bold letters.

Techno-complex and lithic raw material: nd, not defined; limestone refers to siliceous and non-siliceous limestone.

Selected references for localities (see also references therein): 1, Barsky et al., 2010; Espigares et al., 2013; 2, Vallverdú et al., 2014; Mosquera et al., 2015; 3, Goren-Inbar et al., 1994, 2017; Rabinovich and Biton, 2011; 4, Piperno and Tagliacozzo, 2001; Moncel et al., 2019; 5, Aureli et al., 2015, 2016; 6, Cassoli et al., 1982; Marra et al., 2018; Ceruleo et al., 2019; 7, Pawłowska et al., 2014; 8, Konidaris et al., 2018; Panagopoulou et al., 2018; Tourloukis et al., 2018; 9, Wenban-Smith, 2013; 10, Boschian and Saccà, 2010, 2015; Saccà, 2012; Marra et al., 2018; 11, Segre and Ascenzi, 1984; Mussi, 2002; 12, Gaudzinski et al., 1996; Gaudzinski, 1998; 13, Villa, 1990; Santonja and Villa, 1990; Yravedra et al., 2010, 2019; 14, Santonja and Villa, 1990; Yravedra et al., 2010; 15, Santonja and Villa, 1990; Villa et al., 2005; Santonja et al., 2014; 16, Valensi et al., 2011; Moigne et al., 2016; 17, Anzidei et al., 2012; Santucci et al., 2016; 18, Julien et al., 2015; Serangeli et al., 2018, 2021; 19, Mania et al., 1997; Brühl, 2003; Müller and Pasda, 2011; Brasser, 2017; 20, Marder et al., 2011; Rabinovich et al., 2012; Solodenko et al., 2015; Zupancich et al., 2018; 21, Cliquet, 2008; 22, Santonja and Villa, 1990; Villa et al., 2005; Santonja et al., 2014; Pineda and Saladié, 2019; 23, Scott, 2001; 24, Anzidei, 2001; Mussi, 2002; Marra et al., 2018; 25, Aranguren et al., 2019; 26, Turner, 1997; 27, Mazza et al., 2006; 28, Scott et al., 2014; Smith, 2015; 29, Yravedra et al., 2012; Yravedra et al., 2019; 30, Conard and Niven, 2001; 31, Panera et al., 2014; Yravedra et al., 2019; 32, Brühl and Laurat, 2010; Palombo et al., 2010; Diedrich, 2014; 33, Panera et al., 2014; Yravedra et al., 2014; 34 and 35, Weber, 2000; Gaudzinski, 2004.

	LOCALITY	COUNTRY	AGE (KA)	MIS	SPECIES
1.	Barranco León, Level D	Spain	ca. 1400		*Hippopotamus antiquus*
2.	Vallparadís?	Spain	ca. 1000		*Hippopotamus antiquus*
3.	Vallparadís?	Spain	ca. 1000		*Stephanorhinus hundsheimensis*
4.	Boxgrove	England	ca. 500	13	*Stephanorhinus* sp.
5.	Marathousa-2	Greece	500–400?		*Hippopotamus antiquus*
6.	Caune de l'Arago, Level F	France	392±43	12	*Stephanorhinus hemitoechus*
7.	Guado San Nicola	Italy	ca. 360	11/10	*Stephanorhinus kirchbergensis*
8.	Biltzigsleben	Germany		11 or 9 or 7	*Stephanorhinus hemitoechus/S. kirchbergensis*
9.	Biache-Saint-Vaast	France		7	*Stephanorhinus hemitoechus/S. kirchbergensis*
10.	La Cotte de St Brelade	England		7–6	*Coelodonta antiquitatis*
11.	Taubach	Germany	ca. 120	5e	*Stephanorhinus kirchbergensis*
12.	Bolomor Cave, level IV	Spain	ca. 120		*Hippopotamus amphibius*

Appendix 3.2: European Early–Middle Pleistocene localities (both open-air and cave ones) with reported cut marks on rhinoceroses and hippopotamuses. References: 1, Espigares et al., 2019; 2 and 3, Martínez et al., 2010, but see Madurell-Malapeira et al., 2012; 4, Roberts and Parfitt, 1999; 5, Konidaris et al., 2019; 6, Chen and Moigne, 2018; 7, Sala et al., 2014; 8, 9, Brasser, 2017; Auguste, 1995; 10, Smith, 2015; 11, Bratlund, 2000 ; 12, Blasco and Fernández Peris, 2012.

4. HUMAN-ELEPHANT INTERACTIONS DURING THE LOWER PALAEOLITHIC: SCRUTINIZING THE ROLE OF ENVIRONMENTAL FACTORS

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ABSTRACT

The human-elephant interactions during the Lower Palaeolithic are an intriguing issue that has been the subject of several studies, however, the multifaceted aspects of the interaction dynamics are still imperfectly known and divide most of the researchers dealing with this topic. Various sources of evidence point out the contemporaneous presence of Palaeolithic humans and proboscideans during the Early and early Middle Pleistocene of Africa and Eurasia in different ecosystems, environments and climatic contexts. This research aims to scrutinize the role (if any) that non-cultural related factors, such as environmental context, resource availability and fauna functional diversity, may have had in regulating the human-elephant interactions from ~1.5–1.4 Ma to 80 ka (approximately MIS 49 to MIS 5), focusing mainly on the Lower Palaeolithic. We analyze by means of some multivariate statistical analyses (cluster analysis, neighbour joining clustering method, PCA) the environmental context and the human behavior at main sites from the Mediterranean area (North Africa, Arabian Peninsula and Southern Europe), as well as at a few selected Western and Eastern European sites, where butchering activities on elephant carcasses have been firmly documented. The obtained results suggest that: i) the butchery behavior did not substantially change in the course of the late Early and Middle Pleistocene; ii) during the Lower Palaeolithic the human-elephant interactions were more affected by chance rather than by cultural/environmental factors; iii) during the Late Pleistocene, conversely, the exploitation of mammoth carcasses was more related to a hunting activity, selectively targeted to young individuals, although other large games were preferred at least by Neanderthal hunters.

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4.1 INTRODUCTION

> "…. In the forest lashed by the great rain
> Father elephant walks heavily, baou, baou,
> careless, without fear, sure of his strength…"
> (Tracking Father Elephant, translated by Bowra, 1962).

An extraordinary diversity of species, from very specialized to highly ecologically flexible, originated in the course of the long and complex evolutionary history of the polyphyletic and polymorph proboscidean group, which originated in North Africa about 60 million years ago (Gheerbrant, 2009). Proboscidean taxa, including the subfamily Elephantinae, have inhabited the most different environments, such as rain forests, deserts, tundra, savannah, grasslands and bush lands. The higher ecological flexibility a species had, the wider its geographical range was, sometimes attaining a very wide geographic distribution, as in the case for instance of the woolly mammoth *Mammuthus primigenius* (Kahlke, 2015).

The capacity of adaptation, dispersal and diffusion of proboscidean representatives were to some extent similar to the most recent primates and perhaps archaic humans. During the Pleistocene for instance, the recurring climate changes triggered significant modifications in the structure of ecosystems, and the mammal fossil record documents a complex history of dispersal events and species turnovers. The dispersal processes involved different human and proboscidean species. As a result, the geographic range of hominins (Hominina) and proboscideans (i.e., some representative of Mammutidae, Anancinae, Stegodontidae and Elephantidae, in particular elephants belonging to the tribe Elephantini —*Palaeoloxodon*, *Mammuthus* and *Elephas*, as regards to Eurasia) frequently overlapped under a variety of environmental conditions, including even very peculiar ecosystems, such as islands. During the Late Pleistocene for instance, the Flores Island (Indonesia) was inhabited by a dramatically impoverished and unbalanced fauna (Meijer et al., 2010), including the dwarf human species *Homo floresiensis*. The archaic human from the Liang Bua cave, representative of a long-term population that frequented the cave for about 80 years (95–74 to 12 ka), butchered not only giant rodents (e.g., *Papagomys armandvillei*), but also the dwarf proboscidean *Stegodon florensis insularis*; the behavioral capabilities of Liang Bua humans included also the use of fire (Morwood et al., 2005).

The widespread presence of proboscideans in the territories inhabited by *Homo* spp. may have facilitated the human-proboscidean interactions that go perhaps back to the emergence of our own genus, developing throughout time in different ways, from simple coexistence, to opportunistic exploitation by humans, to highly conflicting relationships as documented in some African and Asian countries today (see e.g., Pant et al., 2016; Evans and Adams, 2018; Anuradha et al., 2019; Hulme et al., 2020; Kitratporn and Takeuchi, 2020; Xu et al., 2020).

The cut marks on equid and bovid bones found at Gona (Ethiopia), dated approximately between 2.58 and 2.1 Ma, provide one of the oldest evidence of human butchery activity in a site where proboscidean remains (*Anancus*) are also recorded (Semaw et al., 1997; Semaw, 2000; Domínguez-Rodrigo et al., 2005). Proboscidean remains were present indeed in archaeological levels of African sites, where lithic artifacts and cut marks on medium- and large-sized mammals have been reported, such as Bouri (~2.5 Ma, Ethiopia; de Heinzelin et al., 1999) and Ain Boucherit (Algeria; Sahnouni et al., 2018; Duval et al., 2019). The lithic artifacts and cut-marked bones found at Ain Boucherit in the layers dated to ~1.9 Ma and 2.4 Ma (Sahnouni et al., 2018; Duval et al., 2019), indicated that scavenging hominins inhabited the North African Mediterranean region earlier than was previously supposed, based on the evidence from the nearby Ain Hanek site (Algeria), dated to ~1.8 Ma (Sahnouni et al., 2013).

In Europe, at sites dated to ~1.5–1.4 Ma, where *Mammuthus meridionalis* is recorded, the presence of cut-marked bones of middle- and large-sized herbivores, as well as of bones broken for marrow extraction, provides the earliest evidence of archaic human faunal exploitation. In particular, such kind of evidence comes from two Spanish sites located in the Guadiz Baza basin (Barranco León 5 dated to ~1.4 Ma and Fuente Nueva 3 to ~1.2 Ma, on the basis of biostratigraphical, magnetostratigraphical and ESR data, and to ~1.5 Ma based on cosmogenic nuclides for Fuente Nueva 3 (Espigares et al., 2019, this volume and references therein; Rosell and Blasco, this volume), and from the Italian site Pirro Nord 13 (Chelli-Cheheb et al., 2019, 2020).

Although the coexistence of archaic humans and proboscideans is documented in a number of Early Pleistocene sites during time and across continents, the available data are not compelling enough for either proving or rejecting an exploitation of proboscidean carcasses by humans at the earliest butchery sites recording proboscideans remains. In the absence of firm butchery evidence on proboscidean bones, the same uncertainty concerns the majority of Pleistocene sites, where a spatial association of artifacts and elephant bones is documented. The association of stone tools and proboscidean bones —e.g., Mammutinae, *Mammut*; Stegodontidae, *Stegodon*; Elephantinae (Elephantini: *Mammuthus*, *Palaeoloxodon*, *Elephas*; Loxodontini: *Loxodonta*)— is indeed a recurrent phenomenon, distributed across continents and palaeobioprovinces.

Several hypotheses and tentative explanations have been formulated to account for this association. The actual meaning may change depending on a number of factors, such as the spatial distribution of bones and artifacts, the depositional context, the taphonomic signatures, which may suggest that: i) the spatial association of stone artifacts and elephant remains results from a natural accumulation and is not functionally related to any human activity; ii) the place was visited by humans, who accidentally found the carcass they scavenged; iii) the place was located in a territory, where archaic humans hunted on proboscideans; iv) the place was a butchery site, where the carcass obtainment strategy cannot be identified (cf. Yravedra et al., 2010 and references therein). The frequency of the association and the widespread presence of tools made on elephant bones evidence the important role as a valuable source of food and raw material the proboscideans had for the Lower Palaeolithic humans (e.g., Reshef and Barkai, 2015; Agam and Barkai, 2016; Barkai, 2019a, b). The high nutritional value related to the large amount of flesh and fat a single elephant carcass can provide, could find support in considering that most elephants in central Africa are likely poached nowadays more for their meat rather than for their ivory.

The question whether the Lower Palaeolithic humans were scavengers or hunters is one of the most intriguing and debated issues in literature, and hypotheses and ideas about early human behavior are especially controversial as regards to proboscideans. Although proboscideans were likely pursued and killed by Middle and Upper Palaeolithic hunters in different ways (e.g., by a single individual carrying a spear and stabbing the elephant in the belly or by cooperative hunters as African hunter-gatherers did in historical time) (see e.g., Anzidei et al., 2015 and references therein; Agam and Barkai, 2018; Ichikawa, this volume; Lewis, this volume; Yasuoka, this volume) the debate “hunting vs. scavenging” (which is beyond the scope of our research) is nearly impossible to solve for the majority of the Lower Palaeolithic sites. Moreover, it is worth noting the objective difficulty of detecting whether archaic humans exploited or not elephant remains at several sites recording butchery activity on other large mammals. This is mainly related to the difficulties to identify defleshing traces on elephant bones. It is indeed a challenging task to find such evidence on proboscideans, because the large muscle masses, cartilage, tendons and strong ligaments hamper the contact between stone tool edges and bone surfaces, and if so, the thick periosteum on several bones may prevent any stone tool modification on the bone surface, as confirmed by actualistic butchery observations (Haynes and Klimowicz, 2015).

Firm proofs of the human exploitation of proboscidean carcasses have, however, to be found to avoid misinterpretations in detecting actual butchery sites. The presence of cut marks still remains the most straightforward evidence. Cut marks on mammoth bones have been documented in a number of European Late Pleistocene archaeological sites. During the last decade, detailed studies of faunal remains at various sites led to the identification of butchery activities on elephant remains at some late Early and Middle Pleistocene sites.

The oldest evidence of human butchery activity on proboscideans, however, dates back to the Early Pleistocene of Africa. In the faunal assemblage of HWK EE (Olduvai Gorge, Tanzania), a site older than 1.664 ± 0.0194 (cf. discussion and fig. 2 in McHenry and Stanistreet, 2018), cut marks have been detected mainly on bone surfaces of middle-sized mammals, but also on a proboscidean astragalus (Pante et al., 2018). Later, in East Africa, at the late Early Pleistocene Olorgesaile butchery site (0.99 Ma; Fig. 4.1a, Appendix 4.1), more than 2300 stone artifacts were found surrounding several *Palaeoloxodon recki* bones (Potts, 1989). Sharp flakes could have been used to remove flesh, as shown by cut marks on one elephant rib, some vertebrae and the hyoid bone, where the tongue muscles are attached. In Europe, the oldest proboscidean cut-marked bones (two ribs of *M. meridionalis* about 30 years old) are recorded at the late Early Pleistocene Barranc de la Boella Pit 1 (Spain), together with 125 lithic artifacts including several refitting chert groups (Mosquera et al., 2015; Rosell and Blasco, this volume) (Fig. 4.1a, Appendix 4.1).

Although cut marks on mammoth carcasses are well documented in several Late Pleistocene sites of Europe, very few have been reported in Early and Middle Pleistocene sites. It is interesting to note that, in the course of the Pleistocene the number of elephant butchery sites substantially augmented from the Early to the Late Pleistocene, but the percentage of sites recording cut marks underwent only a moderate increase (Fig. 4.3).

Together with the presence of cut marks and bones intentionally broken for marrow extraction, hints of elephant (i.e., *Mammuthus*, *Palaeoloxodon*) exploitation by archaic humans are also provided by the use-wear analysis of lithic implements and by isotope analysis (e.g., Venditti et al., 2019 and references therein). The spatial association between elephant skeletons (either complete or partially preserved, in anatomical connection or disarticulated showing a moderate dispersion of bones) and artifacts (particularly the presence of refitting) may be considered as an indirect evidence of some butchery activity at the place. At some sites, such as La Polledrara di Cecanibbio (~325 ka, MIS 9, Italy; Anzidei et al., 2012; Pereira et al., 2017), the functionality suggested by the association is confirmed by more firm evidence, e.g., cut marks, use-wear analysis on lithic artifacts, and bones intentionally broken for marrow extraction and artifact manufacturing (Anzidei et al., 2012; Santucci et al., 2016; Cerilli and Fiore, 2018). In some cases, the exploitation can be inferred from the presence of selected elephant body parts carried by humans into their temporary camps, such as the Terra Amata open-air site (~400 ka, MIS 11, France; Valensi et al., 2011), where one of the oldest evidence in Europe of a recurrent exploitation of small fast game is documented (Morin et al., 2019), and caves, such as Spy (MIS 3, Belgium; Germonpré et al., 2014, this volume; Wißing et al., 2016, 2019; Bocherens and Drucker, this volume) (Fig. 4.1a, b, Appendix 4.1).

Based on these criteria, we have selected the late Early to early Late Pleistocene sites studied herein. Our idea was to provide a few hints in order to contribute to deconstructing the intriguing issue of the evolutionary dynamics of human-elephant interactions during time and across space, in the light of the profound late Early and Middle Pleistocene environmental changes. Our purpose is two-folded: i) to appraise the role (if any) that either the ecosystem functioning and environmental factors or simple chance may have had in promoting the butchery activity of the late Early and Middle Pleistocene *Homo* representatives on elephant carcasses, and ii) to highlight the similarities/differences in archaic human behavior at each site in the light of the environmental context, resource availability and fauna diversity.

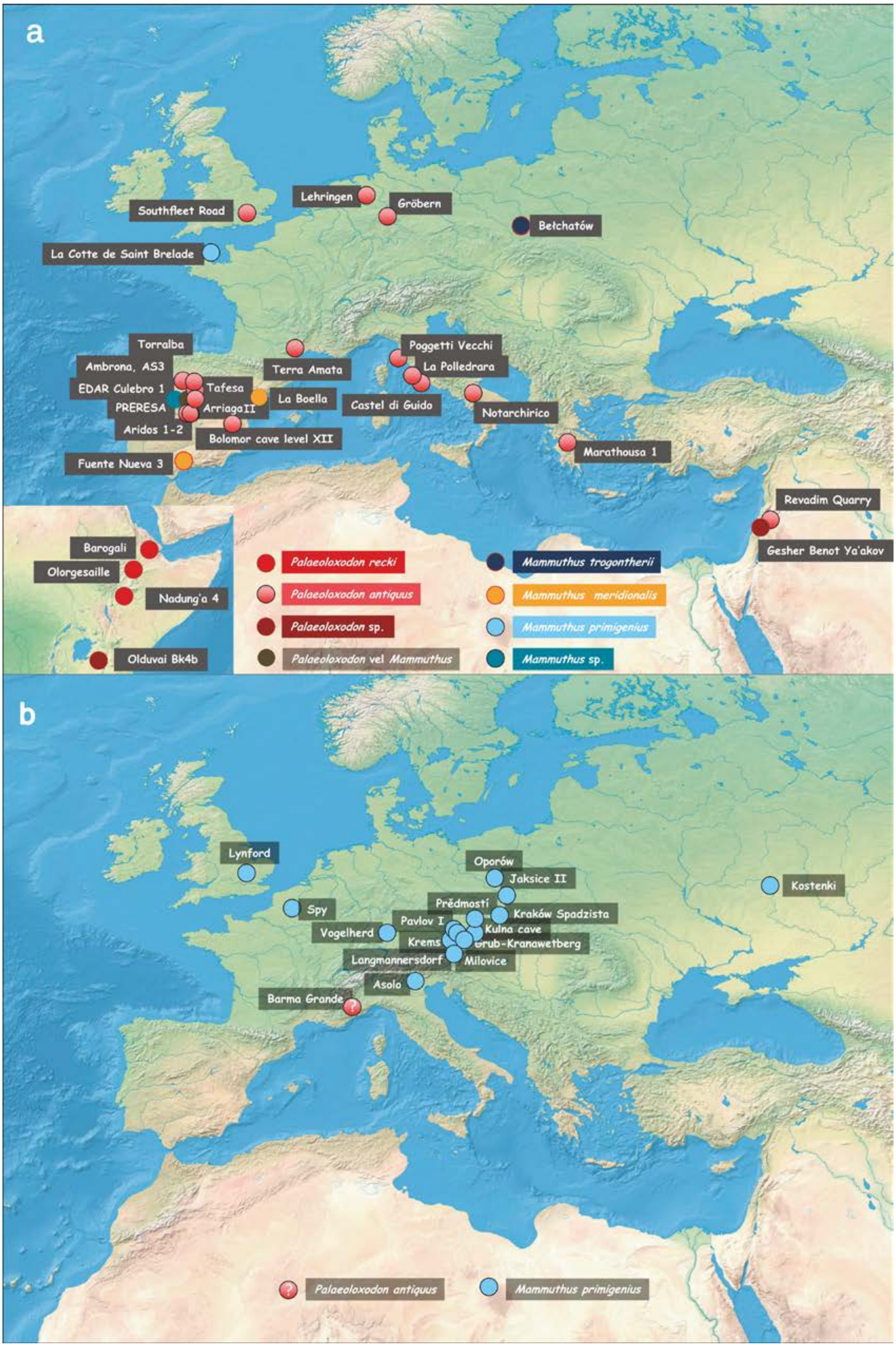

Figure 4.1: Location of the main Early–early Late Pleistocene (**a**) and Late Pleistocene, MIS 4–MIS 2 (**b**) sites recording butchery activity on elephants (*Palaeoloxodon* and *Mammuthus*) (made with Natural Earth, naturalearthdata.com).

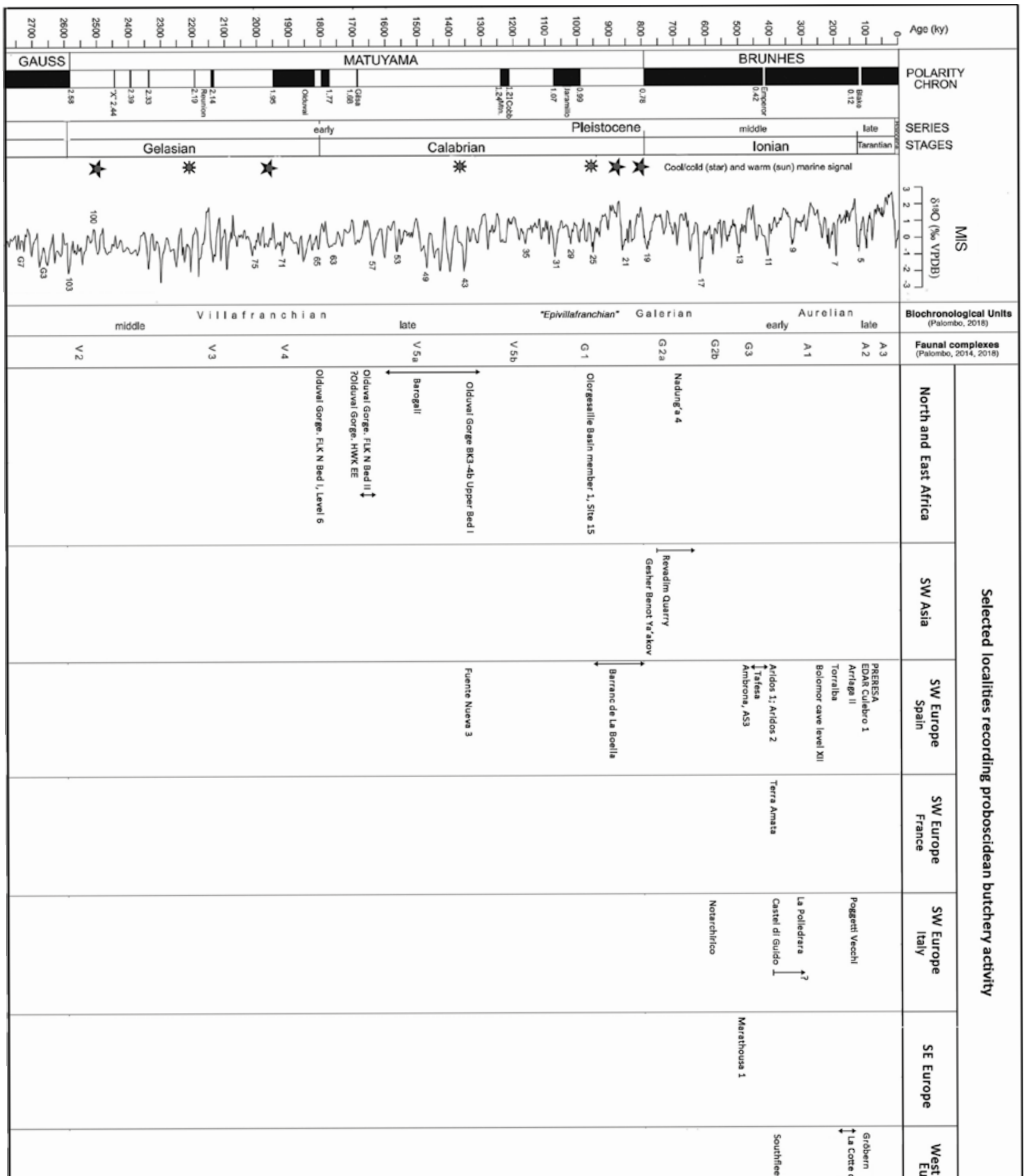

Figure 4.2: Chronological scheme and biochronological setting of the Early, Middle and Late Pleistocene elephant butchery sites selected for this study.

Accordingly, we intend to scrutinize the reliability of the following hypotheses: i) Did the way in which humans exploited elephant carcasses change during the focal time, according to the changing human species and material culture? ii) Did the human butchering activity on elephants depend to any extent on physical/biotic factors, e.g., geographical region, elephant species, vegetation type, functional diversity/ecological structure of mammalian palaeocommunities (particularly number and strength of top predators), human species and material culture? iii) Was the way in which humans interacted with elephants more affected by chance rather than by cultural/environmental factors?

Aiming to scrutinize whether the biotic and physical environmental factors or a simple chance had any role in promoting the butchery activity on elephant carcasses during the late Early to the early Late Pleistocene, we examined three different scenarios: i) around the time that early human groups moved for the first time from Africa to Eurasia; ii) slightly later, when the global climatic conditions underwent the dramatic reorganization known as EMPT (Early to Middle Pleistocene Transition); iii) from the time that the Acheulean culture spread in Europe until the appearance of the Middle Palaeolithic culture, briefly glancing at the period of climate worsening recorded from MIS 4 to MIS 2.

4.2 MATERIAL AND METHODS

4.2.1. MATERIAL

For a firm detection of elephant butchery localities we selected late Early to early Late Pleistocene (MIS 49–MIS 5; Fig. 4.1a, Appendix 4.1) sites, following in a very rigorous and restrictive way the criteria mentioned above, e.g., presence of cut-marked elephant bones or intentionally broken for marrow extraction; elephant skeletons (from articulated to moderately spatially dispersed) surrounded or associated with lithic implements and presence of refitting; use-wear analysis of the lithic implements and isotopic data related to their organic residues, documenting activities referable to butchering (e.g., cutting meat/soft material and scraping off the meat from the hide); and compelling presence of elephant bones carried by humans at the place. Moreover, we excluded from the analysis sites for which data related to the variables we have considered in the statistical analysis (see below) were not informative or complete enough. Accordingly, the selected sites represent only a subset of the numerous alleged sites reported in literature; however, the sample can be regarded as adequate for a first investigation about the role that environmental aspects may have had in regulating the human-elephant interactions during the Lower Palaeolithic. A few European Late Pleistocene sites (MIS 4–MIS 2) have been also included in the statistical analysis for comparison purposes (Appendix 4.1). The total number of the considered localities is 39.

Stratigraphical data, absolute geochronology, palaeomagnetism and biochronological principles were applied for ordering the selected sites in a chronological sequence and gathering them into faunal complexes (see e.g., Palombo, 2009, 2018) (Fig. 4.2). Considering that new discoveries and absolute chronological assessments might change any previously established biochronological scheme, the current chronological assessment can be regarded as the "best-fit" allowed by the available data.

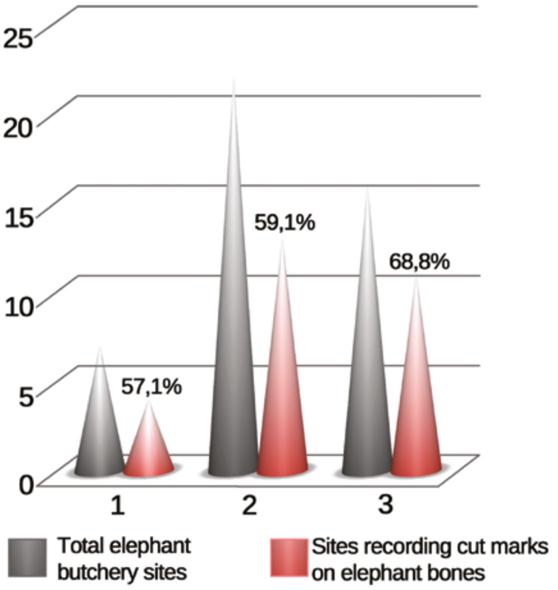

Figure 4.3: Comparison among the number of selected elephant (*Palaeoloxodon* and *Mammuthus*) butchery sites and the percentage of sites recording cut marks on elephant (*Palaeoloxodon* and *Mammuthus*) bones during the Early Pleistocene (1), Middle and early Late Pleistocene (2), and Late Pleistocene (MIS 4 to MIS 2) (3).

4.2.2. METHODS

To estimate the putative influence of physical and biotic aspects on human butchery behavior during time and across space, we performed statistical (univariate and multivariate) analyses by using as cases the selected late Early to Late Pleistocene sites (see above) and a large set of variables.

SELECTED VARIABLES | We selected three main groups of variables for the analysis: 1) variables related to the most general aspects of the site, such as chronology, geographical location and climate; 2) variables considered as appropriate for describing the environmental context and some aspects of the ecosystem functioning, such as the basic different types of landscape (e.g., plain, hill, mountain) and the depositional environments, e.g., the various alluvial contexts, cave, volcanic); of vegetation at the site and/or in the surrounding territory; fauna richness and ecological diversity of the large mammal fauna found at the site (highly, and poorly diversified mammalian fauna assemblage); the species and number of butchered elephants, as well as their ontogenetic age; the amount and spatial distribution of elephant remains; number and power of top predators; 3) and variables related to archaic humans, and their activity and behavior (e.g., human species identified based on human remains or inferred according to the material culture and the age of the site, material culture, cut marks on elephant bones, elephant bones broken for marrow extraction, cut marks and broken bones of other mammals).

We considered the presence of top predators, because it may hamper the access to carcasses by archaic humans and other scavengers [see Konidaris and Tourloukis (this volume) for a discussion on the role of large carnivores in human-elephant interactions]. During the Early Pleistocene for instance, the presence of the saber-toothed cat *Homotherium latidens* and the powerful short-faced hyena *Pachycrocuta brevirostris*, likely hampered human groups to access the carcasses they were scavenging. Therefore, carnivores and humans alternated each other in exploiting carcasses. The same might have sometimes occurred during the Middle Pleistocene, even if the composition of the carnivore guild had changed. During the Late Pleistocene, more organized and better-equipped hunter groups competed successfully even with the most powerful predator, the cave lion *Panthera spelaea*.

As regards to the vegetation, we considered the classic broad vegetation types (e.g., type of forest —rain, evergreen, deciduous, mixed etc.—, grassland, savannah, tree grassland/savannah, shrubland, tundra, taiga, Mediterranean macchia), which substantially differ each other in structure and plant species richness, as well as in environmental productivity (e.g., Mucina, 1997 and references therein).

It is worth noting that the identification of the *Homo* species interacting with proboscideans may be controversial and debated at some sites. In particular, it is generally accepted that *Homo heidelbergensis*, whatever its phyletic relationships could be, was the human species that spread the Acheulean culture widely in Europe. Recently, the attribution to this species of some key human samples has been questioned. For instance, the human remains from the extraordinary rich Sima de los Huesos (~430 ka, MIS 12, Atapuerca, Spain; Bermúdez de Castro et al., 2019 and references therein) have been identified by some scholar as *H. heidelbergensis*, whereas others regarded them as belonging to the Neanderthal lineage (Stringer, 2012; Buck and Stringer, 2014; Manzi, 2016; Roksandic et al., 2018, 2019; Arsuaga et al., 2019; Bermúdez de Castro et al., 2019). In our database, we indicated the most recent in literature specific name given to the humans acting at each site. Concerning the Late Pleistocene sites, if the human species was not specified, we preferred to indicate it as Anatomically Modern Human (AMH), but we have to be aware that many Eastern European sites fall into a chronological interval in which the overlapping/replacement of *Homo neanderthalensis* and/by *Homo sapiens* was in progress.

To facilitate the comparison, sites have been grouped into three main categories, based on the completeness of the elephant skeleton(s): 1) sites with a single carcass found in association with stone artifacts, and with some bones in anatomical connection and few others dispersed within a short distance; 2) sites, where a single carcass was butchered, but the bones are characterized by a certain degree of disarticulation, and bones are dispersed over a small area; 3) sites documenting a polyphasic accumulation of portions of carcasses or individual bones.

MULTIVARIATE STATISTICAL ANALYSIS | The environmental *sensu lato* based resemblance among elephant butchery sites was evaluated by means of two clustering methods (the classic cluster analysis and the neighbour joining clustering method) and one ordination method (principal component analysis-PCA).

Cluster analysis, a multivariate analysis technique by which it is possible to group cases minimizing the distance within each group and maximizing the distance between groups, is a classification method aimed at grouping cases based on the similarity of their attributes. It is commonly used to group a series of samples based on multiple variables that have been defined from each case. Accordingly, we use the hierarchical clustering routine to explore if and to which extent the selected sites cluster depending on their age, geographical position, and physical and biotic environmental characteristics. As clustering technique, we used the unweighted pair-group average method (UPGMA). In UPGMA, the level at which a member (case, herein a site) joins an existing cluster is based on average similarities of all the existing members, calculated from the original matrix of coefficients. Each member of a cluster, therefore, has an equal weight at all levels of clustering. Clusters are joined based on the average distance between all members in the two groups.

The neighbour joining clustering is an alternative, bottom-up (agglomerative) method for hierarchical cluster analysis originally developed for phylogenetic analysis (Saitou and Nei, 1987), but regarded by some as sometimes superior to UPGMA for processing ecological data. In the resulting unrooted dendrogram, two branches from the same internal node do not need to have equal branch lengths, because the branch length is proportional to the amount of change.

We carried out the ordination method to further investigate the structure of the data and better understand the main factors influencing the similarities/differences among the analyzed butchery sites. According to this method, the positions of cases (sites) plotted against two or sometimes three axes (each corresponding to a dimension in space) depict the gradient of greatest variation along the "first" axis, the second largest gradient of variation along the "second" axis etc. In particular, the PCA finds new hypothetical variables (linear combinations of the original variables) accounting for as much as possible of the variance in multivariate data. The eigenvalues and eigenvectors of the variance-covariance matrix or the correlation matrix are determined with the SVD algorithm, highlighting the factors (variables) that contribute more to join/separate cases (sites) each other. We used PCA as a descriptive and exploratory multivariate technique, because it is found to be useful in summarizing all the information that describes the similarities of a set of cases in a small number of dimensions, regardless of the statistical proprieties of the data (Hammer and Harper, 2006).

Analyses were executed with the PAST (PAleontological STatistics) 3.16 software (Hammer et al., 2001).

4.3 RESULTS: A CRITICAL OVERVIEW

4.3.1. CLUSTER ANALYSIS

The cluster analysis was performed in three steps. First, we considered all the cases and variables (Fig. 4.4). Second, we performed the analysis by excluding the "geographical setting" and "chronology" variables (Fig. 4.5a), and then by using the variables related to the environment *sensu lato* and to human behavioral/cultural aspects (Fig. 4.5b), or alternately using one (Fig. 4.5c) or the other (Fig. 4.5d). Third, we considered as cases the sites dated from the late Early to the early Late Pleistocene using either all the variables, or the variables related to the environment *sensu lato* or to human behavioral/cultural aspects.

CLUSTER ANALYSIS OF SITES DATED FROM THE LATE EARLY PLEISTOCENE TO THE LAST GLACIAL MAXIMUM (APPROXIMATELY MIS 49 TO MIS 2) (ALL VARIABLES) | In the dendogram obtained by using all cases and all variables (Fig. 4.4), a chronological ordering mainly prevails. Two well-separated clusters are detectable. The cluster A that includes nearly all the Early to last interglacial Pleistocene localities, and the cluster B that mainly includes the last glacial localities. In the cluster A, the Early and Middle plus last interglacial Pleistocene localities form two sister clusters (respectively A.1.2 and A1.1), gathered in the group A1. The cluster A includes also, as separate rami, the Spanish sites Fuente Nueva 3 (Early Pleistocene, may be older than 1.4 Ma; 1.50 ± 0.31 Ma according to the cosmogenic nuclide burial age provided by Álvarez-Posada et al., 2015, cf. Espigares et al., 2019 and references therein) and Bolomor Cave (late Middle Pleistocene, 152 ± 23 ka). Fuente Nueva 3 is the oldest site with a partial, articulated skeleton of *M. meridionalis* and lithic artifacts (Espigares et al., 2013, this volume and references therein; Rosell and Blasco, this volume). Bolomor Cave is the only site in the database, where bones and teeth of a butchered young straight-tusked elephant were recovered (Blasco and Fernández Peris, 2012, this volume; Blasco et al., 2013; Rosell and Blasco, this volume). The peculiarity of both Spanish sites is highlighted by the quite great distance they show from all other localities gathered in cluster A.

However, some more departures from the general chronological trend are present. For instance, the post-Jaramillo Early Pleistocene Barranc de La Boella Pit 1 (~0.96–0.78 Ma; Vallverdú et al., 2014; Mosquera et al., 2015) falls into the group of the late Middle Pleistocene (MIS 11–MIS 6) localities, as does the early Middle Pleistocene Italian site Notarchirico (A1 level, dated to ~660 ka, MIS 16, although the ecological structure of the large mammal fauna suggests temperate climatic conditions) (Pereira et al., 2015 and references therein). This conceivably depends on the presence at both sites of large cutting tools/Acheulean artifacts (Mosquera et al., 2016; Moncel et al., 2019).

At Belchatów (Poland, Middle Pleistocene, MIS 11 or 9? in Pawlowska et al., 2014; MIS 9 in Marks et al., 2019), cut marks, attributed probably to flesh filleting, were detected on a *Mammuthus trogontherii* rib (Pawlowska et al., 2014). Accordingly, the anomalous setting of the site likely relates to the presence of a representative of the genus *Mammuthus*; that is, together with the species *M. primigenius*, the elephant recorded in the last glacial sites, whereas *P. antiquus* is the most common elephant species butchered at the Middle Pleistocene Southern European sites.

The presence in the group B of the late Middle Pleistocene (MIS 6) levels of the long stratigraphic sequence of La Cotte de St Brelade (Jersey, U.K.; spanning in age from ~238 to 40 ka, Scott et al., 2014 and references therein) and the last glacial site of Spy cave (inhabited by *Homo neanderthalensis* until ~33 ka; Semal et al., 2009) accounts for the overall similarity between the British and Belgian sites. Interesting to note is that the Spanish PRERESA site (OSL dated to ~84 ka; MIS 5a), but whose age is debated ranging from early MIS 6 to MIS 5 (see discussion in Yravedra et al., 2019a, b and Moreno et al., 2019), and EDAR Culebro 1 (dated to ~121 ka by the OSL method and ~150–95 by the AAR method; Manzano et al., 2010), show a degree of similarity with the Middle Pleistocene sites higher than that shown by the German sites of Lehringen (well-known due to the presence of a 2.4 m long wooded spear found within the area of the skeleton belonging to an adult male straight-tusked elephant) and Gröbern. The reason behind the apparently anomalous setting of the German sites cannot be easily explained, because both are correlated to the Eemian (MIS 5e), based on the large mammal assemblages and the

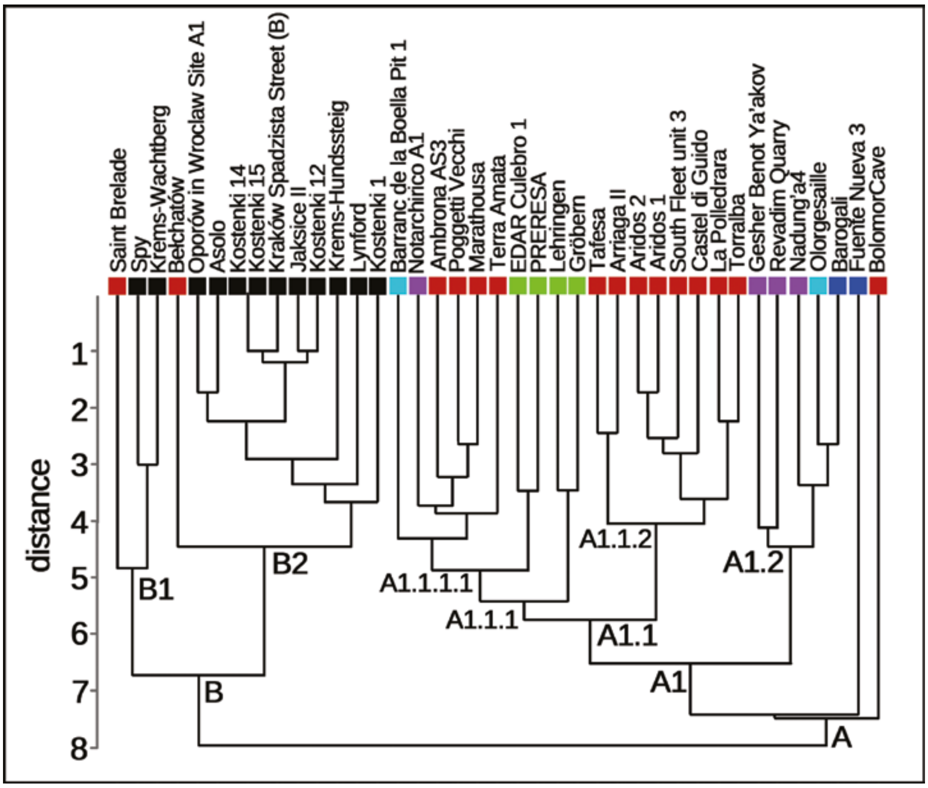

Figure 4.4: Q-mode dendrogram showing how the selected elephant butchery sites ranging from the late Early Pleistocene to the Last Glacial Maximum (from MIS 54–MIS 39 to MIS 2) cluster using all variables. Clusters are joined based on the average distance between all members in the groups (unweighted pair-group average, UPGMA) (for the chronological context see the legend in Fig. 4.7).

vegetation type, which show some similarities to that recorded on various late Middle–early Late Pleistocene European localities (e.g., Litt, 1990; van Kolfschoten, 2000; Weber, 2000). A tentative explanation might relate to the similarity in the geometry of the dispersed elephant bones and in the occasional attendance at the sites of human groups that possibly alternated with carnivores. The same reason could explain the similarity that shows the Middle Pleistocene site of Belchatów with the last glacial sites Asolo, Oporow and Lynford in the cluster obtained by using only the human-related variables (Fig. 4.5d).

All things considered, the results highlight the complex interplay among several factors in regulating the clustering of the butchery sites dated from the late Early Pleistocene to the Last Glacial Maximum. On the one hand, indeed, the geological age of the deposits (on which elephant and human species, and material cultural depend) may be regarded as the variable that mainly contributes to the clustering of the analyzed sites. This is suggested, for instance, by the setting of the most recent sites that generally show certain homogeneity and some degree of similarity. On the other hand, a number of departures from the chronological ordering have been detected. At some cases, we have tentatively explained anomalous clusterings in terms of environmental context, material culture among sites differing in age, presence/absence of a particular elephant species, fauna structure or the peculiar interplay of more than one factors. However, it is sometimes difficult to find a compelling explication.

CLUSTER ANALYSIS OF SITES DATED FROM THE LATE EARLY PLEISTOCENE TO THE LAST GLACIAL MAXIMUM (APPROXIMATELY MIS 49 TO MIS 2) (ENVIRONMENTAL AND HUMAN RELATED VARIABLES) | Assuming that the most influential variable in the site clustering is their geological age, we attempt to further scrutinize to which extent the other factors may have influenced the similarity among the analyzed sites. We performed cluster analyses first by excluding the “geographical setting” and “chronology” variables, and then by using either the variables related to the environment *sensu lato* or to human behavioral/cultural aspects.

Excluding the variables "geographical setting" and "chronology", the clustering does not substantially change, although few variations can be observed with respect to the results obtained by using all the variables (Fig. 4.5a). Worth noting is the setting of the sites dated to the last glacial (MIS 4–MIS 2) that form a sister group A2 with the group A1. A1 gathers nearly all the other late Early (group A1.1) and Middle–early Late Pleistocene localities (A1.2). The localities gathered in A1.2 show a quite high similarity. This accounts for a considerable affinity in physical and biotic aspects among the sites, in particular as regards to the fauna structure and the human behavior. Some peculiarity in the fauna structure and human behavior might explain the odd position of Bolomor, La Cotte de St Brelade and Spy. These three sites gather together with the Austrian Krems-Wachtberg cave (last glacial, MIS 2) in a separate group (B), which shows a great distance from the group A. The unicity of the Early Pleistocene site Fuente Nueva 3 is further confirmed by its distance from all the other localities. The Fuente Nueva 3 position may in part depend on the absence of cut marks, which are instead recorded on M. meridionalis ribs at Barranc de la Boella (the only other butchery place of the species), the remarkable presence of powerful top predators, including the giant hyena *Pachycrocuta brevirostris* that had access to the same mammoth carcass the humans exploited and may have competed with them, and the very warm and humid climate reconstruction for the site (Espigares et al., 2013, this volume; Blain et al., 2016; Rodriguez-Gomez et al., 2016; Rosell and Blasco, this volume).

It should be furthermore underlined that if on the one hand the early Late Pleistocene Spanish localities (PRERESA and EDAR Culebro 1) still fall in the same group (A1.2), gathering the Middle Pleistocene sites (plus the late Early Pleistocene Barranc de la Boella Pit 1), on the other hand the German Eemian sites Lehringen and Gröbern are part of the group A2, which includes sites not only more recent, but also characterized by different environmental conditions, in particular as regards to the climate, a variable still included in the analysis. The unexpected position of the two sites seems to be related more to the combined influence of various biotic environmental factors (the large mammal fauna structure is poorly diversified at both sites) rather than to human related aspects.

The comparison among the dendrograms obtained by using as variable either both the environmental and human related (Fig. 4.5b), or the environmental (Fig. 4.5c), or the human related variables (Fig. 4.5d) shows indeed, that the position of the two German sites remains substantially unchanged when the environmental related variables are taken into account, while they gather together with the Middle Pleistocene sites if the dendrogram is based only on the human related variables.

In the dendrogram based on these variables (Fig. 4.5d), the clustering is mainly related to the geological age of the sites and, in turn, firstly to the human species inferred as present at the site, and secondarily to the material culture; however, other aspects interact also in the site clustering, as suggested by the anomalous position of a few localities (some already mentioned above). In the cluster A, the Early–Middle Pleistocene sites gather together in the groups A1 and A2. It is worth noting, however, the peculiar position of Barranc de la Boella (group A.1.1.2.2). The Spanish Early Pleistocene site shows a high similarity with the Middle Pleistocene Greek site Marathousa 1, dated to ~500–400 ka (Konidaris et al., 2018; Tourloukis et al., 2018 and references cited in both), in spite of the different human and elephant species present at the two sites. In addition, the late Middle Pleistocene Italian site Poggetti Vecchi (~171 ka, MIS 7), recording the presence of H. neanderthalesis (Aranguren et al., 2018, 2019; Capalbo et al., 2018), gathers together with the quite older Spanish sites Áridos 1 and Ambrona A3 (group A.1.1.2.1), as well as Áridos 2 and Terra Amata (France), correlated to MIS 12–MIS 11. At the latter sites, the

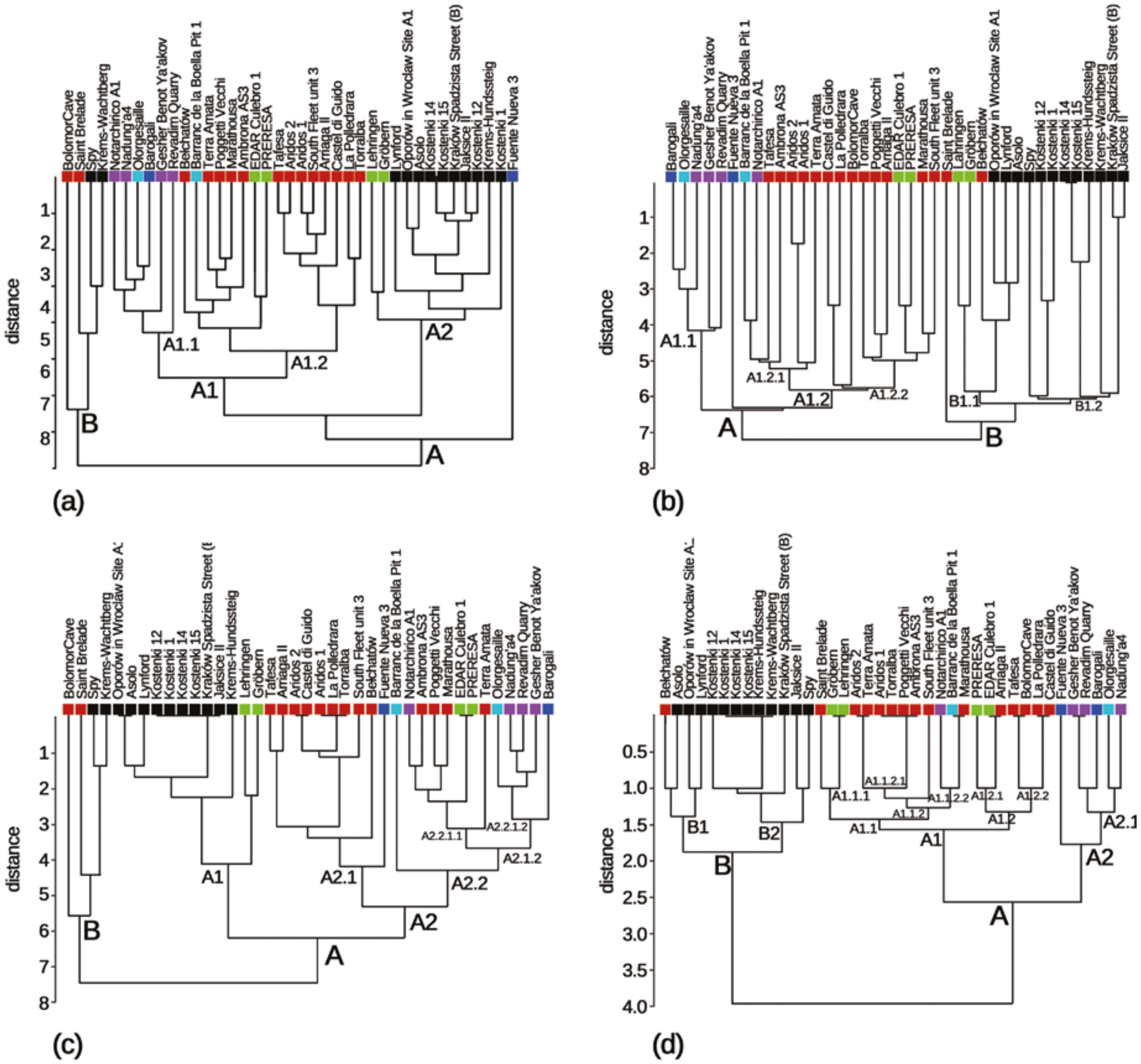

Figure 4.5: Q-mode dendrograms showing how the elephant butchery sites ranging from the late Early Pleistocene to the Last Glacial Maximum (from MIS 54–MIS 39 to MIS 2) cluster excluding from the variables the geographical position and the chronology (**a**); using the environmental and human related variables (**b**), the environmental related variables (**c**), and human related variables (**d**) (for the chronological context see the legend in Fig. 4.7).

presence of *H. heidelbergensis* (or perhaps humans close to those present at the penecontemporaneus site of Sima de los Huesos, see above) has generally been accepted, based on the chronology and geographical position of the sites (e.g., de Lumley et al., 2009; Panera et al., 2011; Santonja et al., 2018 and references therein). The similarity may relate to the human activities at these sites interpreted as residential or butchery places, where humans had an early access to a carcass in a non-competitive situation.

The cluster B includes the sites correlated to MIS 4–MIS 2 recording the presence of *H. neanderthalesis* or Anatomically Modern Human/H. sapiens. They form two sister clusters based mainly on the chronology. B1 includes the MIS 4 and MIS 3 sites, and B2 the late MIS 3/MIS 2 ones. Once again Belchatów (likely MIS 9) shows an anomalous position, gathering together with the localities of B1, close to the Italian MIS 4 site Asolo (Mussi and Villa, 2008), probably due to the aspects discussed above.

It is worth noting that the distance among groups (and sites) progressively decreases as the number of variables reduces and that the similarity increases performing the analysis only using the human related variables. This suggests that, despite all sets of factors contribute to the clustering structure by differentiating the sites even if in different ways, the difference are less pronounced regarding the human behavior, as highlighted by the prevailing influence of variables, such as the human species and material culture, rather than butchery activities.

CLUSTER ANALYSIS OF SITES DATED FROM THE LATE EARLY PLEISTOCENE TO THE EARLY LATE PLEISTOCENE (APPROXIMATELY MIS 49 TO MIS 5) | In the attempt to scrutinize better the factors that might have influenced the butchery activity of early humans, we decided to repeat the analysis focusing on the Early to early Late Pleistocene elephant sites, thus leaving outside the last glacial ones (MIS 4–MIS 2) (Fig. 4.6).

Overall, the dendrogram obtained by using all the variables (Fig. 4.6a) shows a clustering structure rather comparable to those obtained in the previous analyses, but somehow either chronologically (extra-European sites) or geographically (European sites) more consistent. As regards to the chronological setting, some of the inconsistencies showed by the dendrograms obtained including all the localities (Figs. 4.4, 4.5) are still present. Bolomor and La Cotte de St Brelade gather together in a separate cluster (B), the similarity of Fuente Nueva 3 with the other localities included in cluster A is very low, and Barranc de la Boella Pit 1 is close to Acheulean sites ranging in age from MIS 16 to MIS 11, but also the Middle Palaeolithic site Poggetti Vecchi that confirms its peculiarity. The group A1.1. includes also both the Spanish and German early Late Pleistocene, possibly because the multiple influence of a number of variables, including the environmental characteristics.

It has to be noted that excluding the influence of the last glacial sites, Belchatów is positioned in the group A1.2 together with British, Spanish and Italian sites ranging in age from MIS 12 to MIS 7, even though showing the lowest degree of similarity. A high similarity characterizes the Italian site Castel di Guido (Boschian et al., 2019 and references therein) and La Polledrara di Cecanibbio (Anzidei et al., 2012; Santucci et al., 2016; Pereira et al., 2017), which are located in the same territory, are possibly close in age, but show minor differences in the fauna structure and perhaps human behavior.

A few changes can be detected if the chronology and geographical position are removed from the variables (Fig. 4.6a, b, c), although the environmental and/or human-related factors seem to have a major influence in the clustering. This is suggested for instance by the high similarity shown by some couples of sites that differ in age, such as the couples of La Polledrara di Cecanibbio (MIS 9) plus Torralba (MIS 7), and Arriaga II (MIS 6) plus Tafesa (MIS 12–11). La Polledrara di Cecanibbio plus Torralba share a fauna dominated by straight-tusked elephants and aurochs. At Arriaga II and Tafesa, the traces of human activity may result from isolated occupation events related to the processing of elephant carcasses, deer and auroch (Villa, 1990; Anzidei et al., 2012; Panera et al., 2014; Pineda and Saladié, 2019; Yravedra et al., 2019a and references therein; Rosell and Blasco, this volume). The hypothesis finds some support in the way they group together in the dendrogram resulting from the analysis performed by using only the environmental related variables (Fig. 4.6c), where the clustering of sites does not substantially change. We note the reduced distance among group that reaches its lowest value in the dendrogram resulting from the analysis performed by using only the human related variables (Fig. 4.6d). In this case, chronology and human species seem to have a fundamental role in the clustering, although other "human" characteristics, such as artifact technology, anthropogenic modifications and use of sites, also contribute to the group organization. This could confirm the chronological/human species similarity, as well as explain the anomalous positions of some sites. For instance, human species

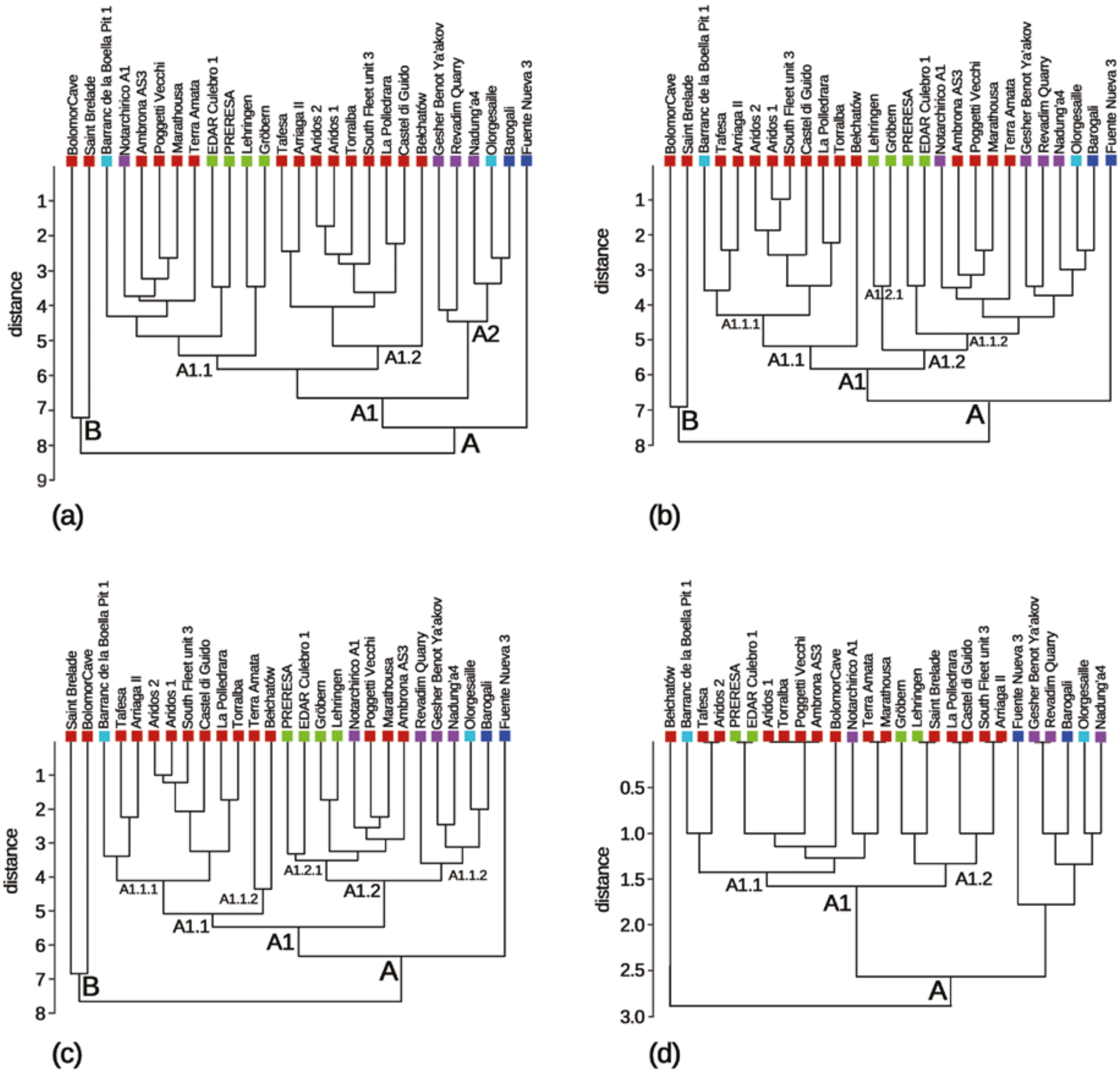

Figure 4.6: Q-mode dendrograms showing how the elephant butchery sites ranging from the late Early to the early Late Pleistocene (from MIS 54–MIS 39 to MIS 5) cluster using all the variables (**a**); using the environmental and human related variables (**b**), the environmental related variables (**c**), and human related variables (**d**) (for the chronological context see the legend in Fig. 4.7).

and material culture account for the new position of Fuente Nueva 3, which gathers with the Early Pleistocene sites (A2), while Barranc de la Boella is still included in the group gathering the Middle–early Late Pleistocene sites (A1).

4.3.2. NEIGHBOUR JOINING METHOD

The results obtained by applying the neighbour joining method roughly support the supposition that all the variables contribute to the clustering structure, even if some environmental and human related aspects are among the most influencing variables (Fig. 4.7). The peculiar position of some sites, such as Fuente Nueva 3, characterized by a rich mammalian fauna with a high diversity of secondary consumers (Espigares et al., 2013, this volume; Blain et al., 2016; Rodríguez-Gómez et al., 2016), might account for the influence of variables related to the environment *sensu lato* characteristics in the neighbour joining. We need to

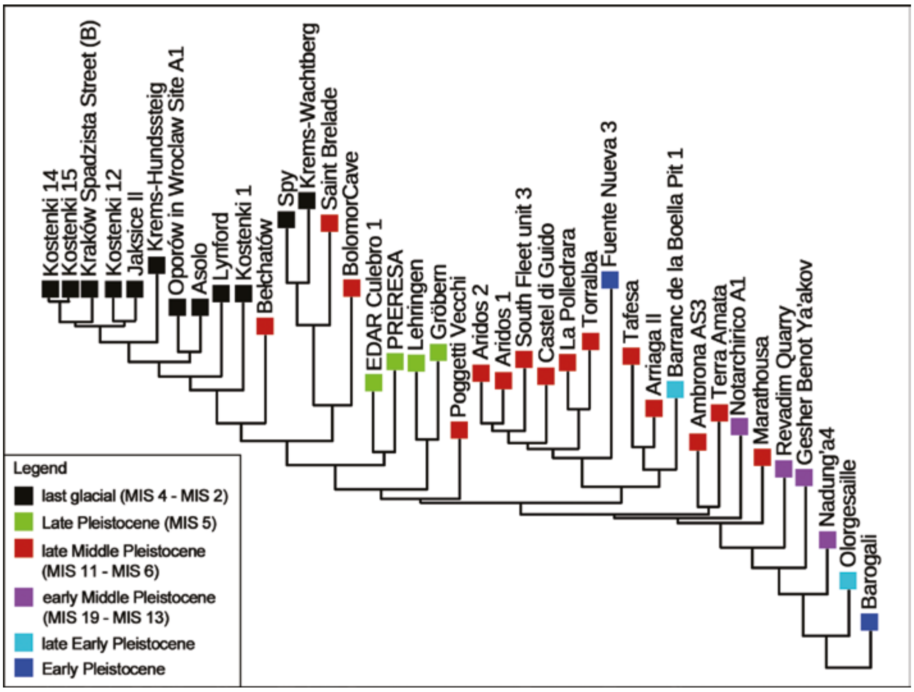

Figure 4.7: Hierarchical clustering tree of the elephant butchery sites resulting from the neighbour joining clustering analysis performed by using all variables.

note, however, that Bolomor Cave, where a generalist human exploited a broad spectrum of prey including young elephants (Blasco et al., 2013; Sañudo et al., 2016; Blasco and Fernández Peris, this volume), is not separated as in the classic clustering analysis (see Fig. 4.4), but joins with La Cotte de St Brelade and Spy, suggesting that the human behavior contributed also to the clustering of these sites.

4.3.3. PRINCIPAL COMPONENT ANALYSIS

The PCA was computed using all the variables, first considering the entire set of sites (Fig. 4.8) and subsequently only the sites dated from the late Early to the early Late Pleistocene (approximately MIS 49 to MIS 5) (Fig. 4.9).

The PCA results obtained from the total dataset roughly confirm some influence of the chronology in the site distribution, but also evidence that of the climate or climate related factors (e.g., vegetation type, which has the highest weight on the first component) (Fig. 4.8). Conversely, some biological factors, such as the fauna characteristics, the number and power of top predators, and human signatures on bones (cut marks and intentional breakage for marrow extraction), are the variables with the lowest weight on the second component, and seem to have negligible influence. Variables related to the butchered elephants, such as species and spatial distribution of bones, and humans (*Homo* species and lithic tool technology) have a major influence in the second component, as well as the chronology of the site to which the human and elephant species are actually related. A chronological assessment is also evident as regards to the first axis. However, the PCA results cannot be regarded as compelling on account of the low values of the two first principal components. The variance accumulated by the first principal component, which accounts for as much as possible of the variability in the data, and the second component, reaches only 35.196% and 15.695%, respectively. Accordingly, the total variance accumulated by the two components is roughly the same percentage reached by the succeeding components, accounting for as much as possible of the remaining variability.

The PCA results obtained reducing the case to the Early to early Late Pleistocene butchery sites

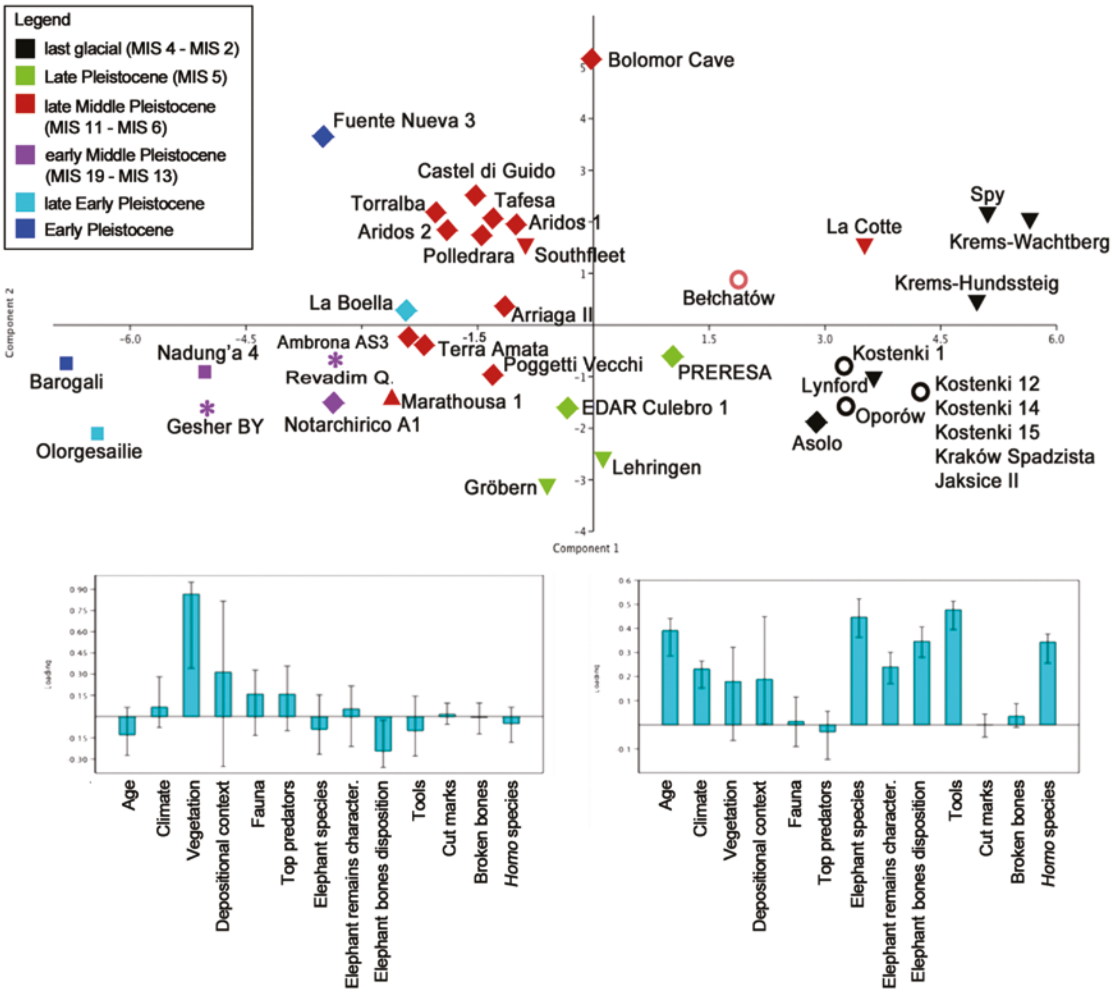

Figure 4.8: Diagram resulting from the principal components analysis (PCA) computed by using all variables and the elephant butchery sites ranging from the late Early Pleistocene to the Last Glacial Maximum (from MIS 54–MIS 39 to MIS 2). The component loadings (below) show the degree to which the different original variables enter into the components 1 (on the left) and 2 (on the right).

(Fig. 4.9) are more compelling than those obtained including the few last glacial sites selected for the purpose of comparison (Fig. 4.8), because the first and second components account respectively for the 45.6% and 42.5% (total 88.1%) of the variance.

The vegetation type is the most influential variable both in the first and second components, as expected due to the key role that the vegetation cover plays in the ecosystem structure and functioning. Conversely, the biological factors (fauna, number and power of top predators, and particularly human modifications on elephant bones) seem to be less influential.

4.3.4. UNIVARIATE ANALYSIS

A further attempt to find any potential trend during time was made by comparing the number of, and the anthropogenic modifications on elephants and other animal bones at the elephant butchery localities (Figs. 4.10, 4.11). The results have to be considered with caution, because the sites (39) we selected in a very rigorous and exclusive way are only a subset of the numerous alleged sites reported in literature. The “absence of evidence”, such as cut marks and/or intentionally broken bones at some sites recording elephant remains associated with artifacts, cannot be considered as the “evidence of

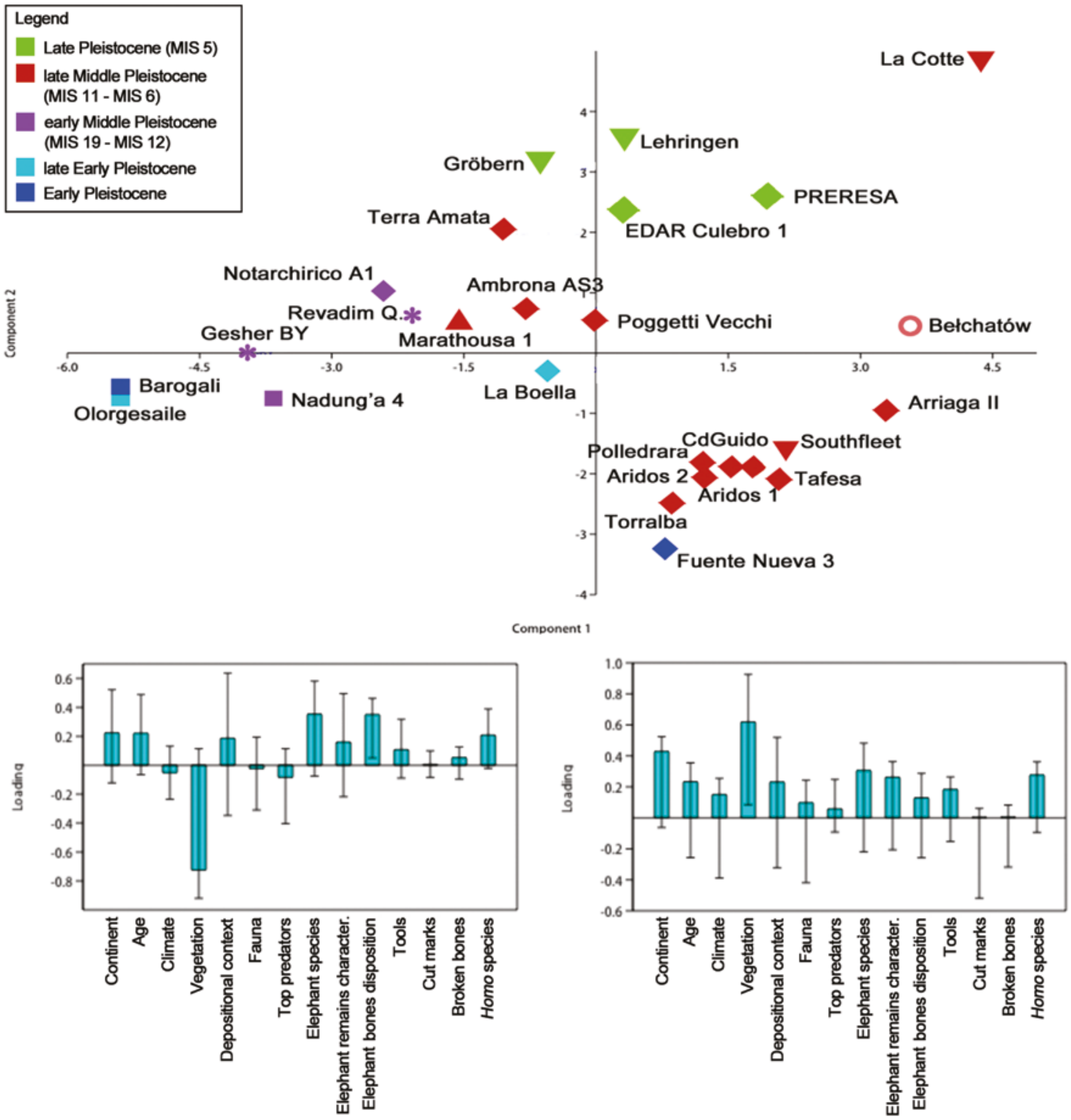

Figure 4.9: Diagram resulting from the principal components analysis (PCA) computed by using all variables and the elephant butchery sites ranging from the late Early to the early Late Pleistocene (from MIS 54–MIS 39 to MIS 5). The component loadings (below) show the degree to which the different original variables enter into the components 1 (on the left) and 2 (on the right).

absence" of elephant exploitation by humans, especially if this kind of activity is documented in other mammals found at the site. Moreover, we include in the analysis only a few among the sites dated to the last glacial (MIS 4–MIS 2) present in the literature, because for most of the sites the basic information, especially related to taphonomic analysis, is missing or not exhaustively provided.

The results (Fig. 4.10) highlight an augment of sites recording anthropogenic modifications on elephant bones (cut marks, percussion marks, fractured bones) from the Early to the Middle Pleistocene and a decrease in the Late Pleistocene, at least regarding the sites selected for the analysis. The significant increase of anthropogenic modifications in the Middle Pleistocene relates possibly to some augment of the exploitation of elephant carcasses, even if it is a challenging task to assert whether this tendency

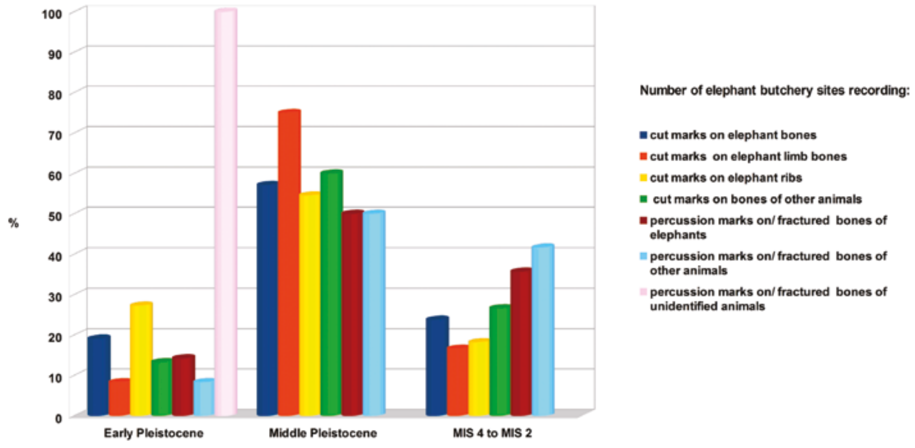

Figure 4.10: Histogram showing the variation of anthropogenic modifications on animal bones in the elephant butchery sites ranging from the late Early Pleistocene to the Last Glacial Maximum (from MIS 54–MIS 39 to MIS 2).

depends mainly on some change in the human behavior or on the interaction of other factors, such as an increase in the occupancy by archaic humans and the need to exploit a large spectrum of resources.

During the Middle Pleistocene, there is also a marked increase in both the percussion marks and bones of elephants and other animals intentionally broken for marrow. Cut marks have especially been detected on ribs, mostly located on their ventral or lateral sides, likely created during the removal of organs or flesh filleting (Fig. 4.11).

The exploitation of elephant carcasses is sometimes associated to that of other mammals. The latter, documented by cut-marked and fractured bones, tends to be dominant in the Late Pleistocene (Fig. 4.11). This fact suggests that the exploitation of proboscideans, in particular of *M. primigenius*, was an important component in subsistence strategies, but secondary to the exploitation of other small and large mammal species.

4.3.5. REMARKS

Overall, the results obtained by processing site characteristics by means of multivariate statistical analyses (cluster analysis, neighbour joining clustering method, PCA) suggest that the butchery behavior did not substantially change in the course of the late Early and Middle Pleistocene.

The environment characteristics, particularly the vegetation type, had, however, an indirect effect on animal and human occupancy, because they affected the productivity, the amount of available resources, the faunal structure, and, in turn, the presence and consistency of human groups in a territory. Conversely, the geographical location and the butchered elephant species likely had a marginal effect. We need to note that in the Early Pleistocene humans and predators succeeded each other in exploiting elephant remains. Nearly the same occurred during the Middle Pleistocene, although the composition of the carnivore guild changed. During the last glacial, better-equipped and organized AMH hunter groups successfully competed with top predators.

The results obtained by processing site characteristics, such as number of compelling butchery elephant sites, and the anthropogenic modifications on elephants and other animal bones by means of univariate statistical analyses, suggest that: i) in the course of the Pleistocene the number of compelling elephant butchery sites significantly augmented; ii) at the oldest sites, cut marks on elephant bones are mainly documented on ribs and scapulae; iii) cut marks on elephant long bones are reported since the Middle Pleistocene; iv) percussion marks and intentionally broken elephant bones prevail in the sites dated to the last glacial phases, apparently in agreement with a progressively increasing systematic exploitation of elephant carcasses during time.

Considering the results of both multivariate and univariate analyses, the hypothesis that during the Lower Palaeolithic the human-elephant

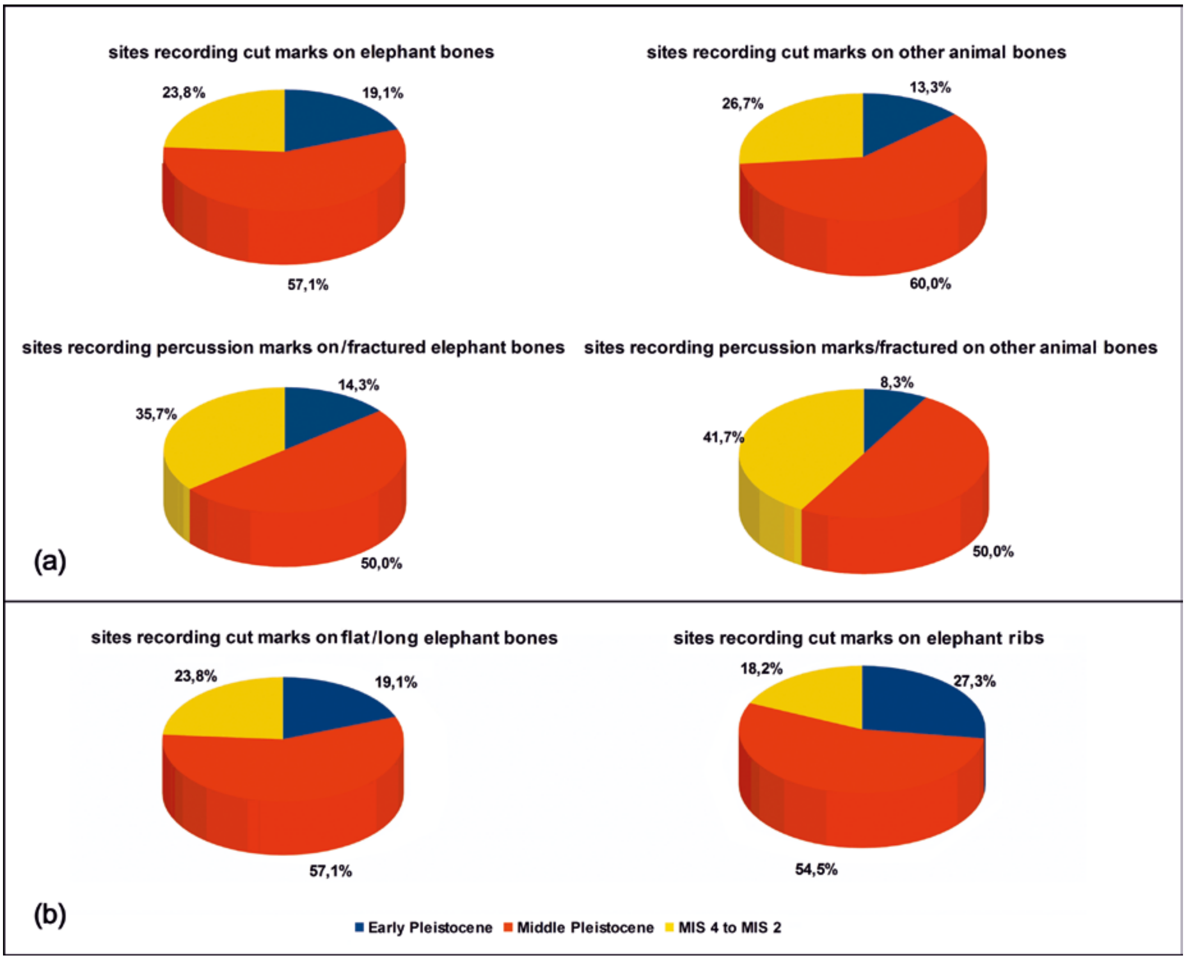

Figure 4.11: Pie charts showing the variation of anthropogenic modifications on elephant and other animal bones (**a**), and on elephant bones (**b**) at the elephant butchery sites ranging from the late Early Pleistocene to the Last Glacial Maximum (from MIS 54–MIS 39 to MIS 2)

interactions were more affected by chance rather than by cultural/environmental factors seems to be conceivable, at least based on the analysis of the available data from the sites selected for this research. During the Late Pleistocene, conversely, the exploitation of mammoth carcasses was more related to hunting activity, selectively addressed to young individuals, although other large games were preferred at least by Neanderthal hunters (see e.g., Germonpré et al., this volume).

4.4 DISCUSSION

During the last couple of decades, the increasing interest on early human behavior in resource exploitation, and the determination to contribute to the debate on scavenging vs. hunting large game, by providing firm evidence supporting one or the other theory, promoted the development of research and a considerable increase in striking data. However, the question of human-proboscidean interactions remains a challenging issue, difficult to deconstruct especially as regards to the Lower Palaeolithic. This is in particular due to: i) the discontinuity and incompleteness of the fossil record in time and space; ii) the defective information available for some sites (for instance the localities discovered, excavated and studied several decades ago, and the nowadays no longer accessible or available collections); and iii) the objective impossibility to identify all the sites, where archaic humans actually

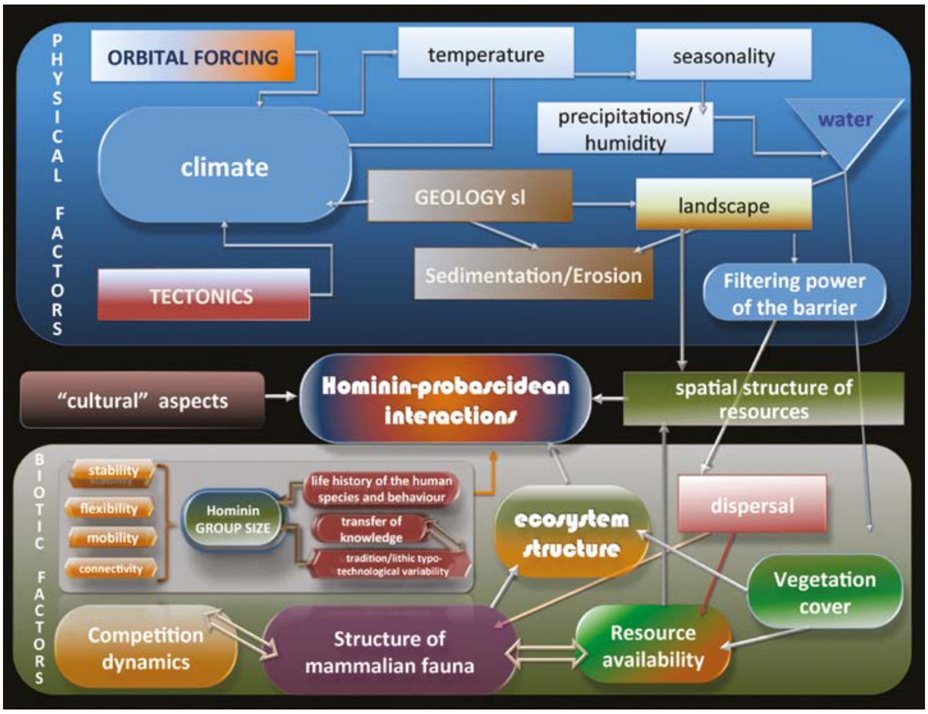

Figure 4.12: Relationships among physical, biotic and cultural factors, and their influence on human-elephant interactions.

exploited proboscidean carcasses for meat. It is the case, for instance, of the numerous sites recording both proboscidean remains and butchery activity on large and small animals, or where dispersed proboscidean remains are associated with artifacts, as it frequently occurs in alluvial depositional contexts.

Manifold factors could interact each other and contribute to promote and shape the way that archaic humans exploited food resources in a variety of environments, from open savannah and grasslands to riparian woodlands. It is indeed a challenging task to deconstruct the conceivable causal factors, remote and proximate, relating to the human behavior and the type of interaction they had with the elephant populations inhabiting their own territory due to the complexity of the interplay network, and related feedback loops (Fig. 4.12).

The behavior of early humans was obviously driven, like in all other living organisms, by the need to maximize the foraging rate and minimize the energetic cost for exploiting available resources and surviving. However, it is a challenging task to hypothesize a univocal evolutionary pattern of human behavior over time and across space. The modalities of human active participation in the ecosystem dynamics actually evolved over time, but the archaic human ability to perceive and adapt to the changing physical and biotic environmental conditions and the varying of its equilibrium, may also have changed during the same slice of time even across the same geographic area. On the one hand, physical and some biotic factors (such as dispersal, turnovers, resource availability, competition dynamics, faunal structure and functional diversity) could have had a major influence in constraining the presence and the occupancy of both archaic human and proboscidean species in a territory. On the other hand, the human-elephant interaction dynamics were likely affected mainly by the archaic human behavior, habits, group size and their dispersion/diffusion on the territory, as well as by any kind of inter- and intra-group cooperation, and material cultural aspects.

Specific evidence and several lines of reasoning suggest that the environmental scenario and its changes throughout time played a significant role in regulating time and mode of human evolution and constraining population dynamics. However, we are far from deconstructing the complex network of causal factors (climate driven environmental changes, catastrophic events, resources availability, geomorphology, landscape characteristics, competition, demographic pressure, cultural aspects such as technology, cognition, communication among others), which may have constrained the human dispersal towards and settlement in any territory during the Early (2.6–0.78 Ma; MIS 103–MIS 19) and early Middle Pleistocene (0.78–0.47 Ma; MIS 19–earliest MIS 12) and, consequently, the conceivable fluctuation in the distribution and density of human groups across space during this time. Periods of dramatic changes in climate regimes and distribution of Palaearctic biota may have played a crucial role in generating adaptive patterns within the primitive human populations, perhaps exerting some influence on human behavioral flexibility in exploiting resources and aggregating either into small groups or rather large bands. However, it remains difficult to answer the somehow speculative question regarding the extent to which such environmental factors may have affected the structure, size, cohesion and intra-group social interactions of the Pleistocene archaic human groups (e.g., Zhou et al., 2005; Hamilton et al., 2017). It is rationale to suppose that physical/environmental factors and "cultural" aspects synergistically act in shaping and regulating prehistoric population size, particularly group size. Disentangling the relationship between the group cohesion/fission and cooperation, and competition due to intrinsic motivation or external factors, is somehow difficult for extant hunter-gatherer populations, and becomes barely possibly regarding the Early Pleistocene humans, as it is to hypothesize the dynamics of intra-group social interactions.

Although it is widely accepted that cooperation among individuals facilitates to achieving optimal results in foraging, and reduces time and energy expenditure in any kind of human activity, a number of questions arise, related to the "cause-effect relationships" among demography, occupancy, productivity, resource exploitation and partitioning, and human behavior and the spillover effects on human-elephant interactions. Consequently, a number of issues deserve to be attentively scrutinized and discussed in more detail. For instance, the matter whether the potential effect exerted on the exploitation and partitioning of resources by the augment of human territory occupancy, and the increase in number and size of populations may have promoted any significant modification of the archaic human behavior. Moreover, the strict selective criteria we have adopted might have led to the exclusion of a number of potential butchery sites, and this may question the hypothesis that during the Lower Palaeolithic the human butchery activity on elephant carcasses was mainly affected by chance. Therefore, the intriguing question arises whether the augment of the number of sites from the Early to the Middle Pleistocene merely related to the increased population density, or due to any beginning of some hunting activity.

Moreover, it is rational to suppose that the group size could have influenced the intra-group cooperation and in turn hunting behavior, but it is a challenging task to find any evidence suitable for inferring the inter-group cooperation dynamics even for the Middle Palaeolithic hunters.

Other intriguing issues deal with the role that the technological innovation, tool efficiency and the progressive developing of archaic human skills may have exerted in shaping the way in which humans interacted with elephants.

Based on the data available in literature, and at least as regards to the sites analyzed herein, no compelling evidence supports the existence of any relationship between the typology and the amount of tools found at a site and potential presence and characteristics of the anthropogenic signatures on elephant bones (cut and percussion marks, intentionally broken bones). In particular, the presence/absence, number and shape of handaxes seem to not correlate with the presence and characteristics of cut marks. It could actually be an expected result due to the scarce likelihood that any kind of cutting tool may leave on elephant bones a signature suitable to persist after taphonomic and diagenetic processes (see e.g., Haynes and Klimowicz, 2015).

A number of studies highlight the key role of small tools in carcass exploitation activities since the Lower Palaeolithic (Venditti et al., 2019 and references therein), although this does not necessarily imply the exclusive use of such kind of tools in sites where also handaxes are present. For instance, at the Middle Pleistocene site of Revadim Quarry (Israel) the use-wear and residual analyses of lithic implements demonstrate the large employment of small flakes in the butchery processes, but also a possible utilization of heavier tools (e.g., handaxes, bifaces, large flakes) for the heavy-duty butchery operations (Venditti et al., 2019; Marinelli et al., this volume). Additionally, the late Middle Pleistocene site La Polledrara di Cecanibbio, where bifaces are absent, is among the sites where small flakes (mainly obtained from a simple reduction sequence and sometimes not or slightly retouched) were systematically employed in the butchering activities (Santucci et al., 2016).

At La Polledrara, as well as in other sites differing in age, human species and elephant butchered species (e.g., Fuente Nueva 3), lithic implements (cores, tools, flakes, some with wear traces testifying for their use on soft animal tissues, and working debris) were associated with an elephant skeleton, documenting the human exploitation of the carcass, likely by scavenging (Espigares et al., 2013, this volume; Santucci et al., 2016).

However, the presence of an elephant skeleton surrounded by tools could have different implications as regards to the origin of the carcass (a hunted elephant? a carcass incidentally discovered? a carcass found during a systematic survey by archaic humans across their home range?). In addition, the spatial connection between skeletal remains and lithic industry may be not enough to indisputably identify a butchery site. An accurate analysis of the depositional context (e.g., stratigraphy, sedimentology, faunal association, spatial distribution of the skeleton bones, particularly presence of skeletal elements in anatomical connection/physiological position, degree of disarticulation and their origin —natural, due to animal intervention and dispersion, or anthropogenic— and taphonomy, with particular attention to the reconstruction of biostratinomic processes) could provide clues valuable to answer the questions.

La Polledrara provides a valuable case study, which documents the cause of death of an adult straight-tusked elephant and the scavenging activity of a human group (likely *H. heidelbergensis*), including a child 5–10 years old (Anzidei et al., 2012). The *P. antiquus* skeleton lies gently bent on its left side with the preserved forelimb bones in anatomical connection, some of them in physiological position. The front limbs bend on themselves, while the left hind limb lies in a sub-horizontal position, stretched backwards. This peculiar position suggests that the elephant slid on the mud-covered bank at the edge of a palustrine zone and was trapped in the muddy sediments of a puddle, where it died. The skeleton is surrounded on both sides by hundreds of lithic implements, produced *in situ* (as the refitting of various flint flakes proves) and used for cutting soft tissues (meat and hide), as indicated by the use-wear analysis (Santucci et al., 2016). Overall, evidence from La Polledrara suggests that the human group scavenged an elephant carcass, which died from natural causes, as it likely occurred at Poggetti Vecchi (MIS 6), where *H. neanderthalensis* butchered the carcasses of straight-tusked elephant (see Aranguren et al., 2019). Moreover, at La Polledrara the distal epiphyses of both femurs are intentionally broken for marrow extraction. On the broken right femur the still in place percussion flake offers further evidence of human exploitation at the site (Santucci et al., 2016), suggesting that the archaic human groups may have visited time after time the zone surrounding the swampy La Polledrara area. The idea that during the late Middle Pleistocene this territory and its resources were attractive for humans is supported by the evidence provided by the neighbouring butchery site of Castel di Guido. At this site, several stone and some bone tools show clear evidence of recycling, suggesting that the bones of large mammals, mostly elephant, were part of a complex subsistence system characterized by hunting and scavenging during a quite long time of permanence or perhaps several phases of human presence at the site (Boschian and Saccà, 2015).

Other sites may represent a single and short phase of use (e.g., Barogali, Olorgesailie basin member 1-Site 15, Gesher Benot Ya'akov, Notarchirico A1 level, Southfleet Road unit 3, Gröbern (?), Áridos 1, Áridos 2, Marathousa 1, and perhaps Asolo), whereas for some others recording an elephant skeleton associated with lithic implements, data are not enough to propose any reasonable hypothesis, as for instance Ficoncella (Italy; MIS 13; Aureli et al., 2015, 2016). Although at the latter site some remains of an adult *P. antiquus* (thus far only partially retrieved from the sediments) were found in close spatial connection with small lithic artifacts showing an original reduction sequence, the sedimentary context, the small thus far investigated area and the rarity of accompanying fauna remains hamper to properly infer the characteristics of this potential butchery site.

All things considered, evidence of elephant flesh and bone marrow consumption, as well as bone artifacts from various Lower Palaeolithic sites, attests that the elephant carcasses constituted a valuable resource for food and raw material, exploited by humans for a slice of time, which could vary from a place to another in an unpredictable way. In the wild, indeed, a number of physical and biotic factors (e.g., temperature, humidity, rain, predator and scavenger animal activity) account for the time that could elapse from the death of an animal and the exposure of skeletal bones.

In the case of Lower Palaeolithic archaeological sites, where there is evidence that archaic humans have exploited elephant carcasses for both meat/marrow and raw material in bone tool production, it is a challenging task to ascertain whether these activities took place or not in a short period of time. This is particularly true considering that bone breakage for marrow consumption did not necessarily occurred immediately after the removal of soft tissues, due to the low rate of marrow fat degradation, still edible after about two months of exposure (Blasco et al., 2019). The arduous to solve issue therefore arises as whether an elephant carcass was intentionally visited many times by the same human group, or by different groups at different times.

Available data on the one hand do not enable us to answer some questions, on the other highlight some issues, which deserve to be scrutinized in depth, as, among others, the association "artifacts-proboscidean bones" in alluvial depositional context. What is, for instance, the actual significance of fluvial deposits, recording elephant remains, bone artifacts and lithic tools (including some used to cut flesh), in the light of the very rare findings of elephant bone fragments with cut marks in this depositional context? For example, at La Polledrara a single cut-marked bone (a diaphysis fragment) was identified among more than 40 elephant bones (analyzed in a selected area of 100 square meters not far from the butchered skeleton) accumulated both on the bottom of the river during flooding events and in the filling deposit (Cerilli and Fiore, 2018; Cerilli et al., 2019). To date, no cut marks have been detected among the remains found in the sediments deposited during the swampy phase giving rise to areas with stagnant and muddy waters, where some elephants became trapped. Accordingly, as mentioned above, the number of butchery sites could be sensibly higher that the number of sites providing firm indisputable evidence of proboscidean carcass exploitation.

The issues discussed above are only a few among the aspects potentially influencing the way in which Lower Palaeolithic humans interrelated with probo scideans, although many others are worth considering and debating, stressing once again the multifaceted, intriguing aspects of the human-proboscidean interaction dynamics during the Early and Middle Pleistocene.

4.5 CONCLUSIONS

Evidence provided by the palaeontological and archaeological record clearly indicates that different proboscidean species coexisted with different archaic human species in different environments, varying in climatic conditions, landscapes, vegetation cover, faunal structure and availability of resources. Accordingly, this study aimed to explore whether and to which extent physical and biotic environmental aspects may have affected human-proboscidean (mainly Elephantini) interactions during time and across space, either as remote and proximate causal factors. To this goal, we analyzed the critically revised environmental context at selected elephant butchery sites (chosen following very critical selection criteria) by processing data by means of statistical analyses.

Taken together, the results support as conceivable the hypothesis that during the Lower Palaeolithic the human-elephant interactions were more affected by the chance to find a carcass, rather than were strictly dependent on environmental factors and/or cultural aspects (*sensu lato*). We are aware, however, that the sites analyzed are only a subset of all the potential late Early–early Late Pleistocene sites, and the results cannot be regarded as exhaustive and conclusive. Although we need more research and data to properly deconstruct the mode and extension of such interaction, the results of this research provide some food for thought.

On the one hand, the chosen statistical approach certainly provides some informative results and fresh clues for setting the matter of the archaic human behavior towards elephants, and the casualty vs. intentionality of elephant carcass processing. On the other hand, the lack of compelling evidence supporting a purported butchery activity on elephants may depend on an unpredictable number of factors that hamper the possibility to know the original environmental context of the human-elephant interactions. In addition to the objective difficulty of creating cut marks on elephant bones, there exist also biases related to biostratinomic and taphonomic processes that may sensibly reduce the amount of information, and the disparity in the amount of sites and information during time and across space. For instance, the Early to early Late Pleistocene archaeological sites yielding elephants remains (mainly belonging to *Palaeoloxodon* and subordinately to *Mammuthus* species) are much more numerous than those, where the characteristics of the elephant remains can be indisputably associated with human exploitation of carcasses. Finally, we do not have, of course, solid data on butchery places that may exist, but have not been found yet.

Keeping these limitations in mind, we can try to answer our focal questions. Regarding the question "did the way in which humans exploit proboscidean carcasses change during time, according to the changing human species and material culture?", the obtained results suggest that the archaic human butchery behavior did not substantially change in the course of the late Early and Middle Pleistocene. The augment in the number of sites seems to be related to the increased demography and territory occupancy, although we are aware that occupancy statistics in palaeontology are biased upward by the intrinsic incompleteness of the fossil record. The magnitude of this bias increases as the number of sites investigated decreased. Moreover, based on the analyzed data, we are unable to conclude on some issues, such as whether any relationship may exist between tools and cut marks, and its potential relevance.

As regards to the question "did the human butchering activity on elephants depend in any extent on one or the other physical/biotic factors", focusing on the late Early to early Late Pleistocene, the results underline the role of environment characteristics, particularly the vegetation type. The latter, in particular, had likely an indirect effect on occupancy, because on vegetation depends the primary productivity, and in turn the faunal structure, the amount of available resources, and, consequently, the presence of human groups in a territory. We could speculate that the higher the amount of resources was, the higher distribution and density a human population had, having as a feedback an impact on the resources partitioning, which may have in turn promoted some changes in human behavior. Concerning the matter of the competition with top predators, the available data suggest that during the Early Pleistocene humans and predators succeeded each other in exploiting elephant remains, as sometimes occurred during the

Middle Pleistocene, although the carnivore guild had changed. During the last glacial (MIS 4–MIS 2), better equipped and organized AMH hunter groups successfully competed with top predators.

Finally, concerning the question whether the human butchery activity on elephants depended mainly on casualty or was in some way related to cultural *sensu lato* and/or environmental aspects, the results seem to support the hypothesis of prevailing accidental findings, at least as regards to the elephant carcasses butchered by Lower Palaeolithic humans. The chance to find a carcass is expected to augment in the course of time, depending on the factors discussed above. Conversely, during the Late Pleistocene the exploitation of mammoth carcasses was more related to a hunting activity, selectively addressed to young individuals, even if other large games were preferred at least by Neanderthal hunters.

Overall, this study highlights once again the complexity of the evolutionary dynamics of human-elephant interactions, and the need to explore all the diverse aspects, even those apparently marginal, in order to be able to answer the many questions still remaining unsolved.

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	Geographical location		**Locality**	**Latitude N**	**Longitude W**
1	Africa	Republic of Djibouti	Barogali	11.09141389	42.0976
2		Kenya	Olorgesailie basin member 1, Site 15	-1.58	36.45
3			Nadung'a 4	4.251111111	35.83361111
4	SW Asia (Levant)	Israel	Gesher Benot Ya'akov	33.008	35.629
5			Revadim Quarry	31.784	34.818
6	NW Europe	United Kingdom	Southfleet Road unit 3	51.440	0.323
7			La Cotte de St Brelade	49.1756167	-2.1881444
8			Lynford	52.520	0.687
9	W Europe	Germany	Lehringen	52.87	9.38
10			Gröbern	51.68	12.44
11		Belgium	Spy	50.478	4.674
12		Austria	Krems-Wachtberg	48.415	15.604
13			Krems-Hundssteig	47.413	15.587
14	S Europe	Spain	Fuente Nueva 3, layer c.III.1	37.71	-2.40
15			Barranc de la Boella, level 2 at Pit 1	41.13	1.16
16			Ambrona, AS3	41.16	-2.498
17			Tafesa	40.35	-3.68
18			Áridos 2	40.29	-3.51
19			Áridos 1	40.29	-3.51
20			Torralba	41.16	-2.498
21			Bolomor Cave level XII	39.0722	-0.2658
22			Arriaga II	40.30	-3.56
23			EDAR Culebro 1	40.30	-3.60
24			PRERESA	40.30	-3.59
25		France	Terra Amata C1	43.698	7.289
26		Italy	Notarchirico, A1 level	40.967937	15.826531
27			La Polledrara di Cecanibbio	41.935	12.302
28			Castel di Guido	41.89	12.28
29			Poggetti Vecchi	42.819140	11.072058
30			Asolo	45.4757	11.5454
31		Greece	Marathousa 1	37.41	22.08
32	E Europe	Poland	Bełchatów	51.3	19.3
33			Oporów in Wroclaw Site A1	51.10	17.02
34			Kraków Spadzista Street (B)	50.053	19.924
35			Jaksice II	50.1436111	20.5038333
36		Russia	Kostenki 1	51.66	39.16
37			Kostenki 12	51.66	39.16
38			Kostenki 14	51.66	39.16
39			Kostenki 15	51.66	39.16

	Absolute Chronology	**Marine Isotopic Stage**	**Elephant species**
1	1.6–1.3 Ma (ESR)	between MIS 54 and MIS 39	*Palaeoloxodon recki*
2	0.992±0.039 – 0.974±0.01 Ma	MIS 28/MIS 27	*Palaeoloxodon recki*
3	~0.780 Ma	MIS 19	*Palaeoloxodon recki*
4	~0.780 Ma	MIS 19	*Palaeoloxodon antiquus*
5	younger than 780 ka and older than 500-300 ka	between MIS 19 and MIS 9	*Palaeoloxodon antiquus*
6	400 ka (AAR MIS 11)	MIS 11	*Palaeoloxodon antiquus*
7	238–240 ka; 238±35 ka	MIS 7	*Mammuthus primigenius*
8	67±5 ka; 64±5 ka (OSL); 53.7±3.1 ka; >49.7 ka (AMS ^{14}C)	MIS 4 to MIS 3 transition	*Mammuthus primigenius*
9	~125 ka	MIS 5e	*Palaeoloxodon antiquus*
10	120 ka	MIS 5e	*Palaeoloxodon antiquus*
11	from ~42.75 ka to 25.67 ka (1)	MIS 3-MIS 2	*Mammuthus primigenius*
12	~28.3–26.8 ka (^{14}C)	MIS 2	*Mammuthus primigenius*
13	28 ka	MIS 2	*Mammuthus primigenius*
14	1.19±0.21 Ma (upper archaeological level); cosmogenic nuclide burial age 1.50±0.31 Ma	?	*Mammuthus meridionalis*
15	between 0.96 Ma and 0.78 Ma	between MIS 27 and MIS 19	*Mammuthus meridionalis*
16	~470–430 ka (2)	MIS 12	*Palaeoloxodon antiquus*
17	---	MIS 12-MIS 11	*Palaeoloxodon antiquus*
18	---	late MIS 11	*Palaeoloxodon antiquus*
19	---	MIS 11, ?MIS 9	*Palaeoloxodon antiquus*
20	200 ka	MIS 7	*Palaeoloxodon antiquus*
21	152±23 ka (AAR-TL)	MIS 6	*Palaeoloxodon antiquus*
22	>133 ka, 134±50 ka (TL)	MIS 6	*Palaeoloxodon antiquus*
23	105±10 ka, 133±28 ka (AAR); 121±7 ka (OSL)	(?MIS 6) MIS 5	*Mammuthus* sp.
24	---	early MIS 6 to MIS 5	*Palaeoloxodon* vel *Mammuthus*
25	C1a level: 380±80 ka (ESR)	MIS 11	*Palaeoloxodon antiquus*
26	from 663±3 ka to 660±3 ka (^{40}Ar/^{39}Ar)	MIS 16	*Palaeoloxodon antiquus*
27	325±2 ka (^{40}Ar/^{39}Ar)	MIS 9	*Palaeoloxodon antiquus*
28	327–260 ka (U/Th-ESR)	MIS 9	*Palaeoloxodon antiquus*
29	171±3 ka (U-series); 170±13 ka (ESR/U-series)	MIS 6	*Palaeoloxodon antiquus*
30	(3)	MIS 4 or MIS 3	*Mammuthus primigenius*
31	500-450 ka (ESR); 450-400 ka (post-IR ISRL)	MIS 12	*Palaeoloxodon antiquus*
32	bout	MIS 11	*Mammuthus trogontherii*
33	66–41 ka (TL-ESR)	MIS 4	*Mammuthus primigenius*
34	between 24.0±0.3 ka and 19.45±0.12 ka (AMS-conventional ^{14}C)	MIS 2	*Mammuthus primigenius*
35	between 40.6±5.7 ka and 30.4±4.6 Ka (TL); between 24.14±0.18 ka and 21.19±0.14 ka (AMS ^{14}C)	MIS 2	*Mammuthus primigenius*
36	between 38.08±5.46 ka and 20.9±1.6 ka (AMS-conventional ^{14}C); between 30.67±2.75 and 30.58±2.74 ka (OSL)	MIS 3 or MIS 2	*Mammuthus primigenius*
37	between 36.28±0.36 and 28.5±0.14 ka (AMS-conventional ^{14}C); between 52.44±3.85 ka and 19.89±1.73 ka (OSL)	MIS 3 or MIS 2	*Mammuthus primigenius*
38	between 37.24±0.43 ka and 26.7±0.19 ka (AMS-conventional ^{14}C); between 47.78±3.48 ka and 26.34±1.92 ka (OSL)	MIS 3 or MIS 2	*Mammuthus primigenius*
39	~30 ka (^{14}C)	MIS 3/ MIS 2 boundary	*Mammuthus primigenius*

	Spatial distribution of elephant bones	*Homo* species identified on skeletal remains	*Homo* species inferred according artifacts and age	Selected references
1	a skeleton partially disarticulated	*H. erectus* vel *H. ergaster*		1
2	a skeleton partially disarticulated	*H. erectus* (?)		2, 3
3	a skeleton partially preserved, bones mainly dispersed		*H. erectus* (?)	4
4	skull with tusks		*H. erectus*	5, 6
5	bones mainly dispersed, some element conjoined		*H. erectus* (?)	7, 8, 9
6	partial skeleton of an adult with bones mainly dispersed bones		*H. heidelbergensis* (?)	10
7	bones mainly dispersed	*H. neandethalensis*		11
8	bones mainly dispersed		*H. neandethalensis*	12
9	bones mainly dispersed		*H. neandethalensis* (?)	13, 14
10	partially articulated		*H. neandethalensis* (?)	14
11	bones mainly dispersed	*H. neandethalensis* / AMH-*H. sapiens*		15
12	bones partially dispersed, some each other articulated		*H. sapiens*	16
13	bones partially dispersed, some each other articulated		*H. sapiens*	17
14	a skeleton partially disarticulated		*H. heidelbergensis* (?)	18, 19, 20, 21
15	disarticulated axial elements of an adult individual		*H. heidelbergensis* (?)	22, 23
16	partial skeleton of a fully adult/old male		*H. heidelbergensis*	24, 25, 26, 27
17	bones mainly dispersed		*H. heidelbergensis*	28
18	a skeleton partially disarticulated		*H. heidelbergensis*	29, 30, 31
19	a skeleton partially disarticulated		*H. heidelbergensis*	28, 29, 31, 32, 33
20	complete skeletal remains		*H. heidelbergensis* / *H. neandethalensis*	26, 29, 32, 34, 35, 36
21	partially represented		*H. neandethalensis* (?)	35, 37, 38, 39
22	bones mainly dispersed		*H. neandethalensis* (?)	28, 35, 40, 41
23	bones mainly dispersed		*H. neandethalensis*	28, 35, 41, 42, 43
24	bones mainly dispersed		*H. neandethalensis*	28, 35, 41, 42, 44
25	bones mainly dispersed		*H. heidelbergensis*	45, 46, 47, 48, 49, 50
26	skull with both tusks still in situ		*H. heidelbergensis*	51, 52, 53
27	bones mainly dispersed	*H. heidelbergensis*		54, 55, 56, 57
28	bones mainly dispersed	*H. heidelbergensis*		58
29	bones mainly dispersed		*H. neandethalensis*	59, 60, 61
30	bones mainly dispersed		*H. neandethalensis*	62
31	a skeleton partially disarticulated		*H. heidelbergensis* (?)	63, 64, 65, 66
32	bones mainly dispersed		*H. heidelbergensis* (?)	67, 68, 69
33	bones mainly dispersed		*H. neandethalensis* (?)	70, 71
34	bones mainly dispersed		*H. sapiens*	71, 72, 73, 74, 75, 76, 77, 78
35	bones mainly dispersed		*H. neandethalensis* / AMH-*H. sapiens*	79, 80, 81, 82
36	bones mainly dispersed		AMH-*H. sapiens*	83
37	bones mainly dispersed		AMH-*H. sapiens*	83
38	bones mainly dispersed		AMH-*H. sapiens*	83
39	bones mainly dispersed		AMH-*H. sapiens*	83

Appendix 4.1: List of elephant butchery sites selected for this study, including some geographical, chronological, palaeontological and palaeoanthropological information, and selected references.

(1) Lower level 42.75 +0.80 -0.65 ka; Intermediate level 29.04 + 0.18 -0.16 ka / 34.58 +0.33 -0.29 ka / 36.92 +0.40 -0.35 ka; Upper level 25.67 +0.13 -0.12 ka (AMS ^{14}C).

(2) An age contemporary of MIS 9 or the end of MIS 11 has been suggested by Falguères et al. (2006), based on combined ESR/U-series dates.

(3) The radiocarbon date of 27.8 ka obtained for the mammoth remains has to be rejected because the bones were consolidated using fish glue.

ESR, Electron Spin Resonance; AAR, Amino Acid Racemisation; OSL, Optically-Stimulated Luminescence; TL, Thermoluminescence; AMS, Accelerator Mass Spectrometry; post-IR, post-infrared Infrared Stimulated Luminescence.

References: 1, Berthelet, 2002; 2, Potts, 1989; 3, Potts et al., 1999; 4, Delagnes et al., 2006; 5, Rabinovich and Biton, 2011; 6, Melamed et al., 2016; 7, Rabinovich et al., 2012; 8, Agam and Barkai, 2016; 9, Solodenko et al., 2015; 10, Wenban-Smith (Ed.), 2013, 11; Smith, 2015; 12, Smith, 2012; 13, Movius, 1950; 14, Weber, 2000; 15, Germonpré et al., 2014; 16, Fladerer et al., 2014; 17, Bosch, 2012; 18, Duval et al., 2012; 19, Espigares et al, 2019; 20, Blain et al., 2016; 21, Duval et al., 2019; 22, Mosquera et al., 2015; 23, Pineda et al., 2019; 24, Shipman and Rose, 1983; 25, Falguères et al., 2006; 26, Santonja et al., 2016; 27, Sánchez-Romero et al., 2016; 28, Yravedra et al., 2019a, 29; Villa, 1990; 30, Santonja et al., 2001; 31, Yravedra et al., 2010; 32, Villa, 1996; 33, Santonja et al., 2005; 34, Shipman and Rose 1983; 35, Santonja et al., 2016; 36, Postigo-Mijarra et al., 2017; 37, Blasco and Fernández Peris, 2012; 38, Blasco et al., 2013; 39, Rosell et al., 2015; 40, Silva-Barroso et al., 2012; 41, Panera et al., 2014; 42, Moreno et al., 2019; 43, Yravedra et al., 2014; 44, Yravedra et al., 2019b; 45, Valensi, 2001, 46–50; de Lumley (Ed.), 2009, 2011, 2013, 2015, 2016; 51, Piperno, 1999; 52, Piperno and Tagliacozzo 2001; 53, Pereira et al., 2015; 54, Anzidei et al., 2012; 55, Santucci et al., 2016; 56, Pereira et al., 2017; 57, Cerilli and Fiore, 2018; 58, Boschian et al., 2019; 59, Capalbo et al., 2018; 60–61, Aranguren et al., 2018, 2019; 62, Mussi and Villa, 2008; 63, Konidaris et al. 2018; 64, Tourloukis et al., 2018; 65–66, Panagopoulou et al., 2015, 2018; 67, Pawlowska et al., 2014; 68, Pawlowska, 2017; 69, Marks et al., 2019; 70, Burdukiewicz and Wiśniewski, 2004; 71, Wiśniewski et al., 2013; 72, Wojtal, 2001; 73, Svoboda et al., 2005; 74, Nadachowski et al., 2011; 75, Bosch, 2012; 76, Wilczyński et al., 2012; 77, Pawlowska, 2015; 78, Kufel-Diakowska et al., 2016; 79, Wilczyński et al., 2019; 80, Wilczyński and Wojtal, 2011; 81, Wilczyński et al., 2015; 82, Wojtal and Wilczyński, 2015; 83, Hoffecker et al., 2010.

5. THE ESSENTIAL ELEPHANT: NORTHWEST EUROPEAN HOMININ ADAPTATIONS THROUGH THE MIDDLE–LATE PLEISTOCENE AND NEANDERTHAL EXTINCTION

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KEYWORDS | elephant exploitation; palaeodiet; palaeoecology; palaeoenvironment; undisturbed site; Pleistocene hominin adaptation; Neanderthal extinction

ABSTRACT

This paper firstly presents the "Ebbsfleet elephant", an instance of Middle Pleistocene elephant exploitation from the southeast United Kingdom. The find is well-dated to fully interglacial conditions in the early temperate part of MIS 11. The association of hominin activity with the elephant remains is clear-cut. The elephant bones comprise the partial remains of an adult male, occurring in near-life position in one well-defined horizon. A scatter of refitting flint artifacts was found in close association, beside the rib area. Although there is no direct evidence as to how the beast died (and whether it was hunted), it seems inescapable that this find represents hominin exploitation of the carcass. The find is then considered from a wider ecological perspective: firstly, for the importance of elephants (and other megaherbivores) for hominin adaptations to more-seasonal environments of higher latitudes, and northward colonization during post-glacial climatic ameliorations as exemplified in MIS 11; and secondly for their importance for the persistence of more-northerly populations during pre-glacial climatic deterioration and cold glacial stages. It is suggested that elephant (and mammoth/rhino) exploitation may have been an important enabling factor for settlement of northern latitudes, and may have been a critical constraint upon hominin range during periods of climatic deterioration. This perspective then leads to the conjecture that Neanderthal extinction in northwest Europe during the last ice age was fundamentally caused by the reliance by both modern humans and Neanderthals on a mammoth-niche, and by the unstainable over-exploitation of this niche by the former leading to the demise of the latter.

5.1 INTRODUCTION

The Volkswagen Symposium "Human-elephant interactions: from past to present", which took place in Hannover (Germany) 16th-18th October

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2019, provided an ideal opportunity to discuss this topic, with a wide variety of contributors gathered from across the world. The diversity of expertise allowed new perspectives to be developed, new critiques of some preconceived ideas, and relevant information to be combined from the varied spheres of the participants. For myself, as a Palaeolithic archaeologist with a primary expertise in lithic artifacts, it provided a valuable opportunity to present the relatively-recent discovery in the UK of the "Ebbsfleet elephant" to a wider audience, and to explore some new ideas about its interpretation. Previous reporting of this find (Wenban-Smith, 2013a) has focused on putting it in a secure Pleistocene dating and palaeoenvironmental framework, reconstructing hominin activity at the site, and considering the lithic remains in relation to wider patterns in the UK and northwest European record. In contrast at the Symposium, I wished to take this level of interpretation as a starting point to consider a wider ecological perspective on the Ebbsfleet elephant find, and on the importance of elephant and other mega-herbivore exploitation for Pleistocene hominin adaptations in the northwest European region.

This approach is followed through in this resulting paper, which presents some conjectures—"conjecture: an opinion or inference based on information that is incomplete or not certain"—for further consideration. The first part (Section 2) recaps the Ebbsfleet elephant find, and summarizes current understanding of its date, and its interpretation in terms of on-the-spot hominin behavior and how the observed lithic technology fits in to the wider UK and northwest European framework. The next section (Section 3) outlines a wider ecological framework for considering Pleistocene hominin adaptations. The history of European Palaeolithic study has been dominated by narratives of lithic technological and typological change (e.g., Bordes, 1950; Breuil and Lantier, 1951; Roe, 1981; Wymer, 1982) across space and through time. However, as increasingly recognised since the later 20th century (e.g., Geist, 1978; Gamble, 1986, 1987, 1993; Roebroeks, 2001), a deeper understanding of the period has to situate hominin adaptations and evolution within the dynamic ecological framework of changing Pleistocene climate, and the complex network of faunal and floral adaptations that constitute the stage for the slow dispersal of hominins from their Pliocene African cradle to their near-global ubiquity by the end of the Pleistocene.

Having outlined some ecological principles to frame the discussion, Section n.4 puts forward the conjecture that megafaunal exploitation (primarily of elephants, although potentially including other megaherbivores such as rhinoceros) was a key enabling factor that allowed northward expansion into higher latitudes during warmer phases of the Middle Pleistocene. Although (as explicated below) entirely consistent with theoretical ecological principles, this notion was initially inspired as a counter-position to that put forward by Surovell et al. (2005). These authors looked at the broad global patterning of proboscidean kill sites, and suggested that they were preferentially located at the margins of areas occupied by hominins through the Early and Middle Pleistocene. They then suggested that this apparent pattern indicates hominin overkill as a driving factor of regional proboscidean extinction. However, it seems intuitively unlikely that the long-term successful and resilient adaptations of these huge beasts—who could be considered "apex herbivores", at the top of an evolutionary pyramid of vegetation exploitation, resistant to predation, and bestriding the Pleistocene world in great numbers—would be so vulnerable to the minuscule impact upon their numbers that could have been wrought by the tiny and fragile hominin populations of the era. Rather, the pattern presented by Surovell et al. might be better understood as reflecting the importance of proboscidean exploitation for hominins as they expanded their range, without necessarily having a negative impact upon proboscidean populations. Taking the Ebbsfleet elephant as one exemplar, this notion is further explored through consideration of the wider evidence for hominin expansion, adaptations and elephant presence in Europe in MIS

11, focusing upon the NW region as defined by Gamble (1986: fig. 3.1) comprising the northern part of France and the UK.

Then, having started by outlining an ecological framework that emphasizes the importance of megaherbivores for hominin adaptations and expansion within the context of one ameliorating phase of Pleistocene climate during which hominins became for the first time relatively widespread across northwest Europe, the last part of the paper (Section n.5) considers how northwest European archaic hominin and herbivore adaptations might respond to a cooling climatic phase, and remain resilient through subsequent later Middle and Late Pleistocene climatic oscillations—right up to the point in the middle of the last (Devensian) ice age, when the Neanderthal lineage suddenly (at a deep Pleistocene timescale) disappeared, and was replaced in west and northwest Europe c. 40,000–30,000 BP by anatomically modern *Homo sapiens*.

This replacement—or apparent replacement—has been the topic of substantial debate for many years (e.g., Mellars and Stringer, 1989; Mellars, 1990, 2004; Akazawa et al., 1998; Klein, 2003; Harvati, 2012; Zilhao, 2014). Very few dispute the observed pattern in western Europe of a rapid replacement in the late Middle Pleistocene of a hominin population with physiological attributes that we characterize as "Neanderthal" by a different population with clearly-different attributes that we recognize as anatomically modern humans. However, there remain widely-contrasting, and deeply-entrenched, positions for the explanation of this empirical phenomenon. Some see the Neanderthal-Modern transition as a misleading artifact of the fossil record whereby a single species has undergone rapid evolutionary change, or whereby the coalescence and genetic mixing of native Neanderthals with an incoming anatomically modern population has led to a hybrid population that is physiologically modern but nonetheless retains significant Neanderthal genetic make-up (e.g., Zilhao, 2014). Many (and perhaps most) others, however, accept that the native west/northwest European Neanderthal population was suddenly replaced by modern humans (e.g., Harvati et al., 2007), although there are widely-varying suggestions for the degree of overlap and the underlying cause of the transition (Soffer, 1994; van Andel and Davies, 2003; Mellars, 2004; Stewart, 2005; Kuhn and Stiner, 2006; Golovanova et al., 2010; Houldcroft and Underdown, 2016; Ko, 2016).

Although it has previously been regularly suggested that the most likely reason for the Neanderthal demise lies in some form of ecological incompatibility for their sustainable co-existence alongside modern humans (e.g., Wenban-Smith, 2007: p. 45; Banks et al., 2008), convincing details as to the precise nature of this incompatibility have yet to be put forward. Here, it is conjectured that, from an ecological perspective, the persistence of the Neanderthal lineage in more-northerly latitudes during cold climatic stages may have been dependent upon exploitation of a mammoth-niche, and the further north, the more dependent. And thus, that the root cause of the Neanderthal demise may have been that they were out-competed in this specific niche by modern humans, who expanded into the Neanderthal world during the middle of the last ice age, providing for the first time direct competition for the specific mammoth-niche that allowed hominin survival so far north in a cold periglacial environment. Direct evidential support for this theoretically-derived scenario is provided in Bocherens and Drucker (this volume) and Germonpré et al. (this volume), complementing previously-published work (Richards et al., 2000; Bocherens, 2009, 2011; Bocherens et al., 2015; Drucker et al., 2017; Wißing et al., 2016, 2019; Wojtal et al., 2019) demonstrating through isotope studies the reliance of both modern human and Neanderthal populations on mammoth meat, and direct instances of mammoth hunting or other exploitation by both groups. This may therefore provide the first instance whereby unthinking modern human over-exploitation of a key resource has had direct and catastrophic impact upon the well-being of a fellow-traveler in the interactive web of adaptation that is life on earth.

5.2 THE EBBSFLEET ELEPHANT

5.2.1. INTRODUCTION AND BACKGROUND TO THE SITE

The “Ebbsfleet elephant” is a partially-complete skeleton of one *Palaeoloxodon antiquus* individual, found and excavated at Southfleet Road on the west side of the Ebbsfleet valley, Swanscombe, Kent (Fig. 5.1). The excavation was part of the huge program of archaeological work in advance of the HS1 (High Speed 1) rail line, linking the Channel Tunnel at Folkestone with the London terminal at St. Pancras. The site was discovered in late 2003, and excavated in conjunction with Oxford Archaeology through spring-autumn 2004. An interim report appeared quite rapidly (Wenban-Smith et al., 2006), and this was followed in due course by a full report (Wenban-Smith, 2013a). Many details —in particular, the strati-

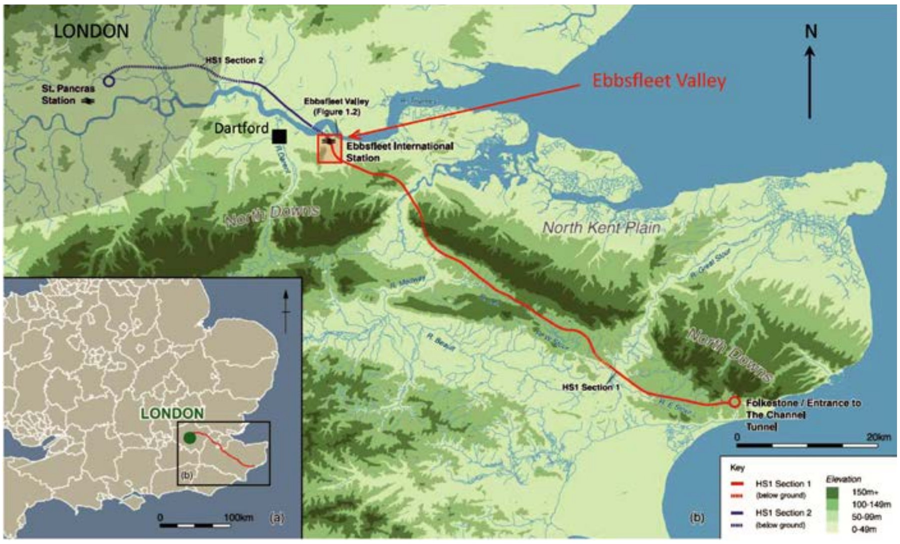

Figure 5.1: HS1 route in the southern UK, and location of Ebbsfleet valley [adapted from Wenban-Smith (2013a: p. 2, fig. 1.1); with permission of Oxford Archaeology and High Speed 1].

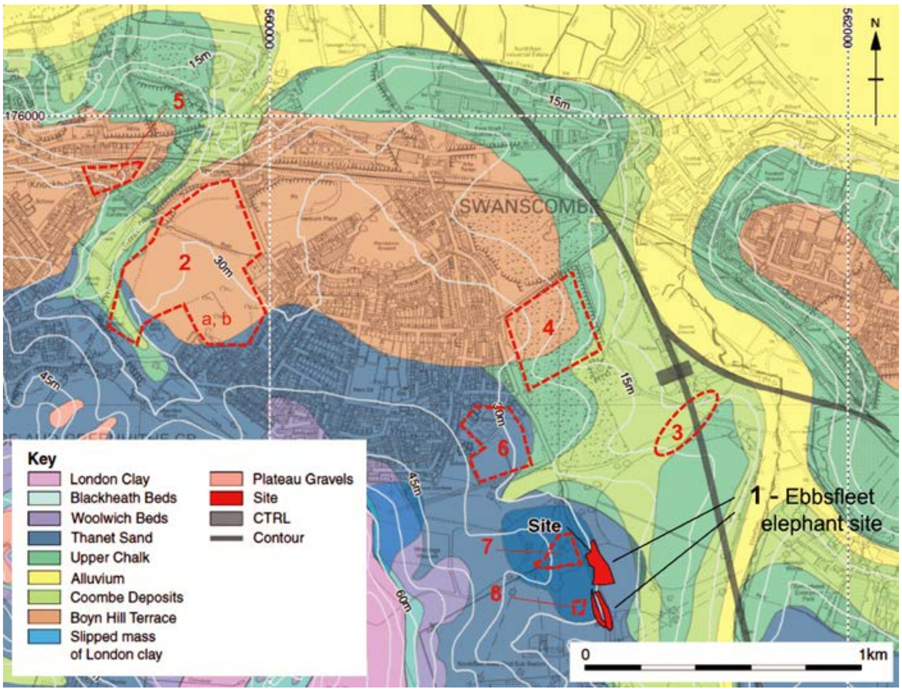

Figure 5.2: The Ebbsfleet elephant site in relation to Pleistocene geological mapping and key local Lower/Middle Palaeolithic sites (see Table 5.1) [adapted from Wenban-Smith (2013a: p. 12, fig. 2.3); with permission of Oxford Archaeology and High Speed 1].

SITE #	NAME	PALAEOLITHIC FINDS	REFERENCES
1	HS1 Southfleet Road - Ebbsfleet elephant site	Undisturbed elephant butchery site (associated with Clactonian material), overlain by a fluvial gravel rich in handaxes	Wenban-Smith (2013a)
2	Barnfield Pit, Swanscombe	Classic sequence of sand, gravel and loam deposits; Clactonian in lower deposits; handaxes („Acheulian“) in upper deposits, along with Swanscombe skull	Wymer (1968: pp. 334–346), Conway et al. (1996)
- a	Barnfield Pit, Skull site, Wymer excavations 1955-1960	Three different parts of Swanscombe skull found close to each other, on separate occasions between 1935 and 1955	Swanscombe Committee (1938), Ovey et al. (1964)
- b	Barnfield Pit, Waechter excavations 1968-1972	Investigation of Lower Gravel and Lower Loam, c. 50 m NE of skull site area	Conway et al. (1996)
3	Baker's Hole Levallois site	Prolific Levalloisian industry from chalky valley-side slopewash deposits	Smith (1911), Wenban-Smith (1995)
4	Rickson's Pit	Abundant Clactonian, handaxe and Levalloisian remains recovered, but not with good provenance	Wymer (1968: pp. 351–352)
5	Dierden's Pit/Yard	Handaxes, flakes, and rich faunal and molluscan preservation, in places	Wenban-Smith (2009); White et al. (2013)
6	Swan Valley Community School	Boyn Hill/Orsett Heath terrace (Swanscombe Middle Gravels) with abundant lithic artifacts (handaxes, cores and flakes) and an elephant tusk	Wenban-Smith and Bridgland (2001)
7	Bevans Wash-pit	22 handaxes and 4 debitage; also reports of elephant/mammoth teeth	Spurrell (1890), Wenban-Smith (2004: Stopes Site 14)
8	Ebbsfleet Green	Undisturbed palaeolandsurface with refitting Clactonian lithic industry, thought to be contemporary with the Ebbsfleet elephant	Wenban-Smith (2014)

Table 5.1: Key Lower/Middle Palaeolithic sites in the Swanscombe area (see Figure 5.2).

graphic phasing and depositional interpretations of some sediment beds, and some lithic artifact counts and interpretations— were substantially revised in the final report, so it is the latter (which is freely downloadable) that should be consulted for further more-detailed information on the site. This section provides a brief recap of the elephant, the associated lithic artifacts relating to its hominin exploitation, and the rich associated palaeo-environmental remains that allow us to locate the elephant and its hominin exploitation precisely in the Hoxnian (MIS 11c, stage Ho IIb-c). It is, however, worth noting that the elephant was just one aspect of the site, which had 11 main stratigraphic phases, and evidence of Palaeolithic activity spanning from very early in MIS 11 (and perhaps before) through to its end (and perhaps after).

The Ebbsfleet elephant site (Fig. 5.2, Site 1) is located within a rich landscape of surviving evidence from the Lower and Middle Palaeolithic on the southern side of the Thames (Fig. 5.2; Table 5.1), in its lower tidal reaches where it heads east from London towards the North Sea. Here, the higher ground above the southern bank of the river is lined by a series of Middle Pleistocene terrace deposits that have been noted since the late 19th century for their abundant evidence of early hominin activity, in association with mammalian fossils and other palaeo-environmental remains. These de-

Deposit phase	MI Stage	Date BP	Stratigraphic unit	Height, mOD	Palaeolithic archaeology
III	11-10/10/10-8?	?300,000–?375,000	Upper Gravel	c. 33–35	Uncertain, few reliably-provenanced material other than technologically undiagnostic debitage
			Upper Loam	c. 32–33	
II	11	?375,000–?400,000	Upper Middle Gravel	c. 28–32	Acheulian - Handaxes (mostly pointed) with thick partly-trimmed butts, often large and well-made, but also small and crude; also occasional cores, debitage and ad hoc flake-tools [Swanscombe Skull was found at the junction between Upper and Lower Middle Gravels]
			Lower Middle Gravel	c. 27–29	
I	11	?400,000–425,000	Lower Loam	c. 25–27	Clactonian - Cores, debitage, simple flake-tools (often single or double notches), and very occasional crude „proto-handaxes"
			Lower Gravel	c. 23–27	

Table 5.2: Barnfield Pit, Swanscombe: sequence, dating and Palaeolithic industries.

posits—originally categorized as the Swanscombe 100-ft Terrace, or the Boyn Hill Terrace, but now more-properly labelled as part of the Orsett Heath Formation (Bridgland, 1994)—have been investigated at numerous sites, and mostly represent fluvial deposition in the UK's Hoxnian interglacial (MIS 11). Perhaps the most important site is at Barnfield Pit, Swanscombe (Fig. 5.2, Site 2), located c. 1.5 km to the northwest of the Ebbsfleet elephant site. This was one of the first UK sites where systematic and controlled investigations established changing lithic industries through a deep Middle Pleistocene sequence (Smith and Dewey, 1913, 1914). It is also one of only three British sites where early hominin skeletal remains have been found, represented by an incomplete skull, different parts of which were found on three separate occasions between 1935 and 1955 (Swanscombe Committee, 1938; Ovey, 1964). A further programme of work was carried out at Swanscombe in the 1970s, involving investigation of the lower parts of the sequence—the Lower Loam— which proved to contain a series of undisturbed remains from palaeo-landsurfaces, with a non-handaxe Clactonian lithic industry (Conway et al., 1996). The Barnfield Pit sequence is summarised below (Table 5.2), as it provides an important framework for contextualizing the nearby Ebbsfleet elephant site within the UK's MIS 11 Palaeolithic record.

The Ebbsfleet is a small south-bank tributary of the lower Thames. Its valley cuts northward into the Thames through the Boyn Hill/Orsett Heath Formation, and thus its contained deposits—which include the celebrated Baker's Hole Levalloisian site (Fig. 5.2, Site 3)— mostly post-date MIS 11. However, deposits from MIS 11 are preserved further south up the Ebbsfleet's valley, higher up the valley on its west side, and it is here that the elephant site is located (Fig. 5.2, Site 1).

5.2.2. DISCOVERY, EXCAVATION, CONTEXT AND DATING

The majority of construction work for HS1 took place in the central and lower parts of the Ebbsfleet valley, relating to installation of the high-speed line and Ebbsfleet International station. The elephant site was discovered during bulk ground reduction for a new access road down from the higher ground to the southwest of the new station. It was very unfortunate that the bulk ground reduction removed the rear half of the elephant, and any associated Palaeolithic artifacts before the site was discovered. This has unfortunately compromised the eventual scope of interpretation of some aspects of behaviour at the site; in particular, consideration of matters such as group-size, intensity of exploitation of the carcass, and the import/export of lithic tools to the site from elsewhere, are hindered by uncertainty over the missing evidence.

The first sign of the elephant was when the tusks were uncovered by a mechanical excavator (Fig. 5.3a). After this, the rest of the elephant remains were carefully excavated by hand (Fig. 5.3b–d), and they were found to comprise the front half of a single animal. Many bones were in poor condition, although a few were remarkably pristine. The larger bones showed weathering due to pre-burial exposure and had also suffered in situ degradation due to shear stress and compression during their burial. Some smaller bones, especially some of those from the front feet found near the head area of the beast (Fig. 5.3c), were in very good condition; these must have been buried relatively rapidly and their small size made them more resistant to in situ degradation.

The elephant bones were associated with a scatter of approximately 60 mint condition flint artifacts. This scatter was centred immediately beside the rib area, and there were also several flint artifacts amongst the concentration of elephant bones (Fig. 5.3d). The faunal and lithic remains were all found at a well-defined horizon c. 10cm thick within a much thicker (2–3m) bed of grey clay (phase 6) that extended across most of the wider site (Fig. 5.4). The grey clay under the elephant contained various sub-horizontal orange/red bands c. 2cm thick, slightly hardened at their top. These are interpreted as short-lived palaeo-landsurfaces within a build-up of sediment that mostly took place in a wet environment. The elephant horizon was defined by a dark brown organic-rich bed within the grey clay. Enough pollen was found in this bed (Turner et al., 2013) to (a) identify the local environment as a swampy alder carr within a wider landscape that was predominantly-forested, although with some more-open areas, and (b) to attribute the deposits as laid down in the early temperate sub-stage II of an interglacial, and to identify that this was most-likely the Hoxnian interglacial (MIS 11c).

These dating and palaeo-environmental attributions were reinforced by other lines of evidence, in particular by mammalian biostratigraphy and amino acid analysis for dating (Parfitt, 2013a, b; Penkman and Wenban-Smith, 2013), and by interpretation of other mammalian and ostracod faunal remains from the same horizon as the elephant (Parfitt, ibid.; Whittaker et al., 2013). The grey clay generally contained rare and widely-scattered identifiable bones of other mammals (such as rhinoceros). However, there was a minor stream channel stratified within one part of the grey clay about 15m to the east of the elephant. This channel was infilled with a white tufaceous silt/sand, which contained small vertebrate and molluscan remains in abundance, as well as some remains of larger vertebrates such as macaque, deer and rhinoceros. Of particular importance was that several articulating bones of one foot of the elephant were found near the bank of this channel, and that another bone from the same foot was found within the channel-fill. This provides a firm foundation for linking the elephant skeleton and its associated pollen remains with the rich palaeo-environmental and dating evidence from the tufaceous channel-fill. It was thus possible to confidently attribute the elephant remains to the early temperate zone HO-II of the UK's Hoxnian interglacial (MIS 11c), and more specifically to relate them to the period covered by sub-zones IIb-c, dating c. 420,000–410,000 BP.

The elephant skeleton was located at the west edge of what would have been the marshy floodplain in the floor of the Ebbsfleet valley, and at the foot of what would have been a slope rising up further to the west, capped by Tertiary clay beds. The model for site formation is that the water level at the valley floor was periodically fluctuating, at the same as there being a —possibly episodic— input of fine-grained slopewash sed-

Figure 5.3: The Ebbsfleet elephant under excavation: (**a**) shortly after discovery, tusk remnants freshly exposed; (**b**) tusks fully uncovered, in very poor condition but retaining life position; (**c**) spread of thoracic, rib and foot bones; (**d**) flint core amongst elephant bones, note broken bone caused by mechanical excavator before site was discovered.

iment down the slope from the west. Thus the elephant died at a point in the landscape where short-lived dry landsurfaces at the edge of the floodplain were regularly becoming submerged by rising water, and where slopewash deposition was leading to sediment aggradation. The elephant carcass initially lay on a stable dry landsurface at the edge of the floodplain, and then must have remained exposed for several years, enough for some of the bone surfaces of larger bones (skull and limb bones) to have become exposed and weathered (Parfitt et al., 2013). The water level of the floodplain then rose, and they were then covered by clay-silt deposits slipping down onto the wet floor of the floodplain from the west. The bones were probably initially enveloped in a peaty clay-silt deposit forming in a marshy zone at the edge of the valley floor, which subsequently became dried and compressed as overlying sediments continued to accumulate through the ensuing millennia.

As shown below in Figure 4, the elephant remains and the adjacent flint scatter are closely juxtaposed, in an area of the site where other faunal and lithic remains are otherwise very scarce. As outlined above, the elephant skeleton must have been gently buried where the animal first fell, and not been transported or substantially-disturbed post-mortem. Several of the elephant bones are in near-anatomical position in relation to each other, and the overall dispersal of the bone scatter is restricted within an area of 2 m × 5 m, commensurate with minor post-death decay and animal disturbance. The flint artifacts found beside it are all in mint (or very fresh) condition. The lithic assemblage comprised 77 artifacts in total, of which 12 were small chips <2 cm maximum length. Their fresh condition and their recovery from a tight area beside the elephant provided a strong initial indication that these too are undisturbed. It is also beyond reasonable doubt that they were causally linked with the elephant skeleton since the lithic

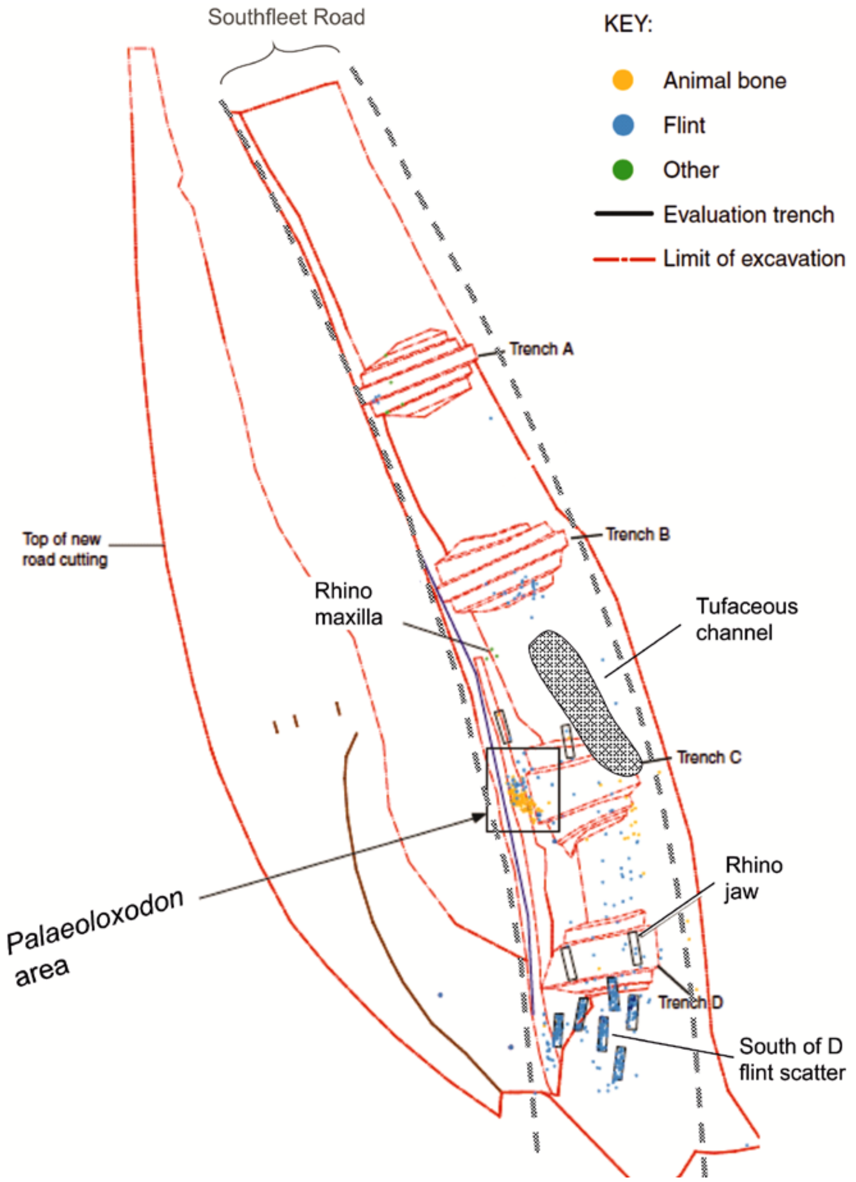

Figure 5.4: The Ebbsfleet elephant site (phase 6): the elephant area in relation to other key aspects of the site [adapted from Wenban-Smith et al. 2006: p. 475, fig. 4d; with permission of Oxford Archaeology].

scatter respects the bone concentration and occurs at the same specific horizon, and these remains occur in an area of the site where lithic and faunal remains are otherwise scarce and widely-dispersed within the phase 6 clay.

5.2.3. LITHIC REMAINS AND ON-SITE BEHAVIOR

A refitting study was carried out (a) to further investigate the degree of disturbance, and (b) to investigate the hominin activity relating to the lithic remains. The results of the refitting (Table 3; Fig. 5.5) showed that most of the artifacts (nearly 80%, excluding the small chips) were refittable into one of 7 groups A–G. The largest group (C) had 24 constituent pieces, including the core and one flake with visible damage suggesting use as a tool. This refitting group included the full sequence of reduction debitage from very early in the sequence through to the eventual core, which was also present. Some large flakes were missing from the refitted sequence, and it is suggested that these

Refitting group	Summary description	Artifacts (n)	Technological notes
A	Refitting flake sequence, without core	7	Sequence of flakes from early parts of a core's reduction, from distinctive banded grey/white flint with green cortex, but core not found
B	Large core, with several flakes	7	Large remnant cylindrical core, with sequence of refitting flakes from early in its reduction
B?	Debitage, probably related to Group B	1 1	Cortical irregular waste from end of a cylindrical nodule, probably start of Group B reduction sequence Small secondary flake, the notch from making notched flake-tool - very similar flint raw material as Group B
C	Moderate-sized core, with numerous flakes	24	Reasonably complete reduction sequence from initial decortication of nodule through to core; refitting sequence includes a flake with use-damage indicating use as a flake-tool
D	Broken percussor	7	Broken flint percussor - appears to have broken in use, and then used further after breaking
E	Broken core	3	Core that has broken into three pieces from one blow, one of these pieces then knapped further, although the flake removed is missing; nor are flakes from earlier stages of reduction present
F	Broken flake	2	Medium-sized flake, partly-cortical, that has broken on knapping
G	Broken cortical flake	2	Small cortical flake that has split during percussion
-	Core	1	Large core on southern fringe of elephant lithic concentration
-	Flake-tools	3	Two utilised flakes and one notched flake-tool, two of them from amongst the elephant bones
-	Flakes	6	Mostly from edge of elephant lithic concentration
-	Irregular waste	2	-
-	Chips <2cm	11	-
Total		77	

Table 5.3: The lithic assemblage by the elephant: refitting groups and other elements.

were selected for tool-use and exported from the immediate area of their manufacture. This is where it becomes particularly frustrating to have lost the rear end of the elephant. They might have been left only a few yards beyond the excavated area, for instance by its rump. Alternatively, they might have been totally removed from the elephant area for use elsewhere. Knowing which of these behaviours took place has major implications for our understanding of hominin capabilities and adaptations at this time, so it is very unfortunate to have lost this evidence here.

Group B (7 pieces, including the core) had a relatively large remnant core of good quality flint, that had been started at the spot, but then curiously had been abandoned after only a few removals and left substantially unknapped. In contrast, Group D (7 pieces) did not represent a sequence of reduction, but the shattered remnants of a globular flint nodule used as a percussor. It is suggested that this percussor broke while trying/failing to remove a large flake from the Group B core, since this core shows batter marks at a point consistent with an attempted flake removal. The Group A reduction sequence represents the early stages of reduction from raw material that likewise was probably found nearby, although the core and later reduction stages of this sequence were not recovered. Group E,

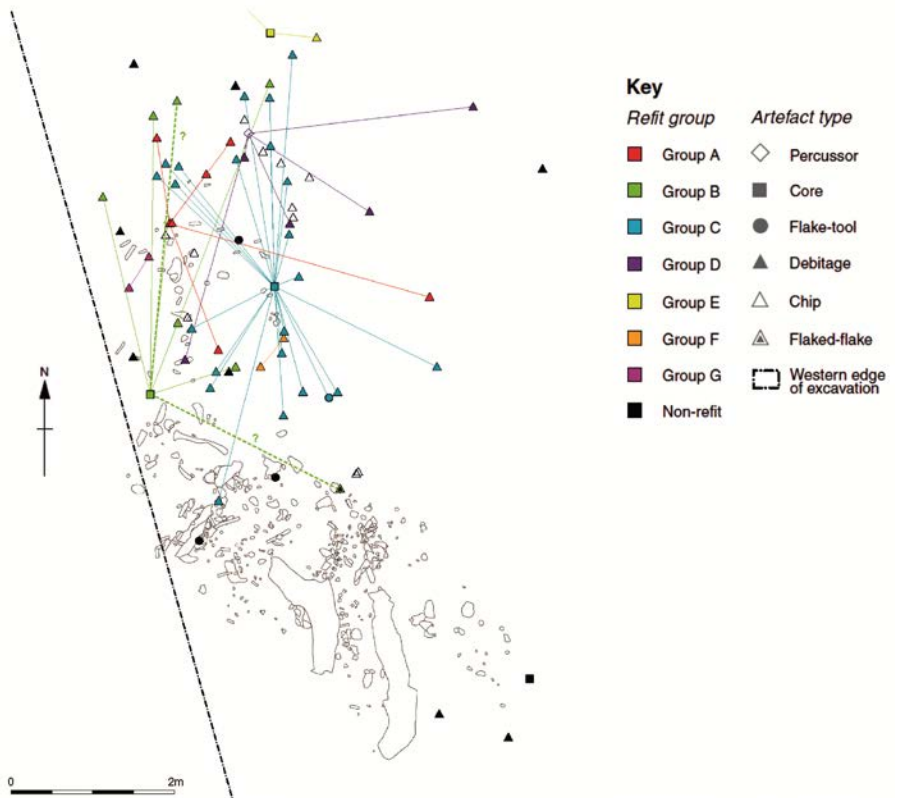

Figure 5.5: The Ebbsfleet elephant: skeletal layout and lithic refitting groups [adapted from Wenban-Smith (2013a: p. 344, fig. 17.4); with permission of Oxford Archaeology and High Speed 1].

in contrast, represents a core for which the early stages of reduction were not recovered, and which seems to have been abandoned on the spot after breaking due to an internal flaw.

Three non-refitting flake-tools were identified, as well as the above-mentioned flake-tool that was part of refitting group C. One of these was a small flake that had had a single notch knapped on one side. The other three flake-tools did not have secondary working, but had otherwise-sharp edges with visible zones of minor chipping/scaling interpreted as use-damage. The notched flake-tool was found in the centre of the lithic scatter, but the other three were found at its southern edge, in amongst the elephant bones (Fig. 5.5). There was also evidence of a missing notched flake-tool represented by the secondary flake that produced the notch. Therefore there was direct evidence of 5 flake-tools, and there were also 5–6 medium-large flakes missing from the refitted sequences, which it is suggested were also chosen for use as tools.

The conclusion of the refitting study was that the lithic scatter had undergone minimal or no post-depositional disturbance, and that the flint artifacts were recovered in almost exactly the places they had been left by hominin activity. It seems vanishingly unlikely that, in an area of the site where lithic and faunal remains are otherwise very scarce, this quantity of knapping activity and tool-use could take place right beside (and partly amongst) an elephant carcass and be unrelated to it. The absence of observed cut-marks on any of the elephant bones should not be taken as indicating an absence of human butchery. As observed by Haynes (1991: pp. 185–186) and Crader (1983), exploitation of such large animals as elephants for meat and/or other tissue would often leave no trace on the remnant bones. And in this case, the surfaces of the larger bones have in any case been subject to pre-burial weathering and exposure that would have removed any traces that might have been left. Therefore, the Ebbsfleet elephant evidence is confidently interpreted as a location where early hominins used flint tools to exploit a carcass of *Palaeoloxodon antiquus*.

The lithic remains show that some on-the-spot knapping took place (Groups A, B and D) of flint raw material that was probably collected nearby - there was a good source in the valley-side <50m to the west —as well as some tools and part-knapped raw material (Group E) being brought to the site. The knapping activity involved the production of numerous flakes, and then some seem to have been chosen for use without further modification, and others for simple modification (such as creation of a single notch with one knapping blow) before being used. Functionally, these tools would have been ideal for cutting tasks, even heavy-duty tasks such as cutting elephant hide and flesh, so that is the interpretation of the activity at the site.

Several flakes and flake-tools were found that could not be linked with on-the-spot reduction. Here again, it is frustrating not to have the full site preserved, since this would have revealed whether they were made by the elephant, or brought in. In total, the number of pieces of raw material represented in the surviving lithic assemblage is c. 12. This could be taken as indicative of the number of incidents when the elephant was exploited for meat (or other nutritional elements), although it remains uncertain whether this should be envisaged as having taken place as one event for a larger group, or on repeated occasions by fewer individuals. Considering the amount of food represented, and its nutritional importance in terms of key dietary requirements such as fat and essential vitamins (Ben-Dor et al., 2011; Brown et al., 2013), it would seem likely that it would be repeatedly exploited as long it was nutritionally viable. This period was envisaged as being of the order of weeks in the original report on the site (Wenban-Smith 2013b: p. 367). However, Boschian and Saccà (2015) and Boschian et al. (2019) suggest that parts of a megaherbivore carcass, particularly marrow, could maintain nutritional value for much longer, for many months or even up to a year in certain circumstances. It is also noteworthy that none of the elephant remains —including the well-preserved foot bones, part of the fatty pad of the foot which would have been desirable to carnivores— showed any sign of animal gnawing, suggesting that the hominins protected access to the carcass from other carnivores.

Based on the evidence that we do have (and thus without agonising on the unknown missing evidence) activity at the site involved a combination of tools made/used/abandoned on the spot, and also tools for which there is no evidence of on-site manufacture; these latter may, therefore, have been brought to the site from elsewhere, in anticipation of their use. Thus the most-plausible model for interpretation of the site is that a fresh carcass was initially exploited, maybe by a band of hominins with as few as 2–4 members, with on-the-spot raw material discovery and tool production/abandonment. And then the carcass was repeatedly visited over the following weeks/months, maybe bringing cutting tools or part-reduced cores to the known carcass location, followed by their export or discard.

Variations on this model might involve less frequent visits by a larger hominin group, or tethering of local mobility to the area of the carcass while it was being exploited, so as to protect it from other carnivores. Unfortunately preservation of Middle Pleistocene archaeological landscapes that allow investigation of behaviour from this era at this level of detail across the landscape almost don't exist; the only exception to my knowledge being the Boxgrove landsurface that survives intermittently over several hectares in the old Eartham Pit (Roberts and Parfitt, 1999). And even at Boxgrove, the excavated areas are too small to encompass more than about 10 seconds of Palaeolithic pedestrian movement to cross them, so this level of interpretation remains out of reach until we find, and fully excavate, a palaeo-landscape of Boxgrove scale. This would have to be envisaged as a major multi-decadal project, requiring huge investment, but with correspondingly major returns in increasing our understanding of Middle Pleistocene hominin adaptations.

5.2.4. PALAEOLITHIC ELEPHANT HUNTING? AND WIDER CONSIDERATIONS

It is uncertain how the elephant died, and what role hominins might have played in its death. It was a large adult male in its prime (c. 45 years old), so this is a beast that would not normally have died from natural causes, and that would have been resistant to carnivore predation. Although it intuitively seems unlikely, there is documented evidence in the modern era of humans killing elephants with simple spears (e.g., Zwilling, 1942), and modern evidence of elephant hunting with (albeit metal-tipped) spears in the eastern Congo Basin by the Mbuti hunter-gatheres (Icjikawa, this volume). It is known from finds at Clacton (Wymer, 1985: pp. 264–285), Schöningen (Thieme, 1997) and Boxgrove (Pitts and Roberts, 1997) that wooden spears were part of the technological capacity of hominins of this era, and the Eemian (MIS 5e) elephant carcass at Lehringen (Adam, 1951; Gaudzinski, 2004) was found with what seems to be a wooden spear in its rib cage, so hunting was a feasible possibility for the demise of the Ebbsfleet elephant, and cannot be ruled out. Also, see the review by Agam and Barkai (2018), which clearly identifies that elephant hunting by Middle Pleistocene hominins was both feasible, and is also documented in the archaeological record. Adult males might also have regularly become injured in the course of fighting each other when in must, and this could have then made them vulnerable to hominin predation. One possibility that can be ruled out, however, is the long-standing trope (e.g., White, 2012) in relation to prehistoric hominin exploitation of elephant remains that the beast was rendered vulnerable by being entrapped in marshy sediment; the elephant bones were resting on a flat and undisturbed palaeo-landsurface, which must have been firm and dry when the carcass first came to rest there.

Technologically, the lithic industry is focused on the production of sharp-edged flakes that could be either be used unmodified as cutting tools, or which were used as blanks for simple notched flake-tools, also ideal for cutting tasks. While the lithic assemblage by the elephant is maybe too small to characterise a lithic industry, a much more substantial concentration of >1750 flint artifacts was found in the site area "south of D" at the same horizon as the elephant and only 30m to its south. This much larger assemblage showed exactly the same technological characteristics as that beside the elephant (Wenban-Smith, 2013c), and it seems inescapable that they are the contemporary products of the same hominin group, or certainly a broadly contemporary group sharing the same cultural practices.

Within the context of the UK's culture-historical Palaeolithic narrative, the site is important as providing a clear representation of the Clactonian industry, characteristic of the initial re-occupation of the UK in the Hoxnian climatic amelioration following the end of the Anglian glaciation. Although this topic was the subject of debate in the later 20th century (McNabb and Ashton, 1992; Ashton et al., 1994; Wenban-Smith, 1998), the Ebbsfleet elephant site seems to have moved the dial (McNabb, 2020) in establishing that the early Hoxnian occupants of the UK practised a distinctive non-handaxe core/flake/flake-tool industrial tradition that can be labelled as Clactonian. Handaxe-based Acheulian traditions become prevalent later in the Hoxnian, and the focus of debate should now be whether or not this represents a further influx of settlement into the UK, or whether the observed change represents in situ technological development. As previously argued (Wenban-Smith, 1998, 2013d) it seems very unlikely that two contemporaneous and geographically proximal hominin groups could maintain culturally distinct lithic industrial traditions in northwest Europe in the Lower Palaeolithic.

Although a UK-focused instance, this is an example of an interpretive issue of pan-European, and pan-global, Palaeolithic relevance. The "tribal" culture-historical interpretation of the European Palaeolithic record as a narrative of movement around the continent of distinct and culturally conservative hominin groups is deeply rooted in simplistic 19th and early 20th century perspectives on the archaeological record derived from externalist perspectives on contemporary hunter-gatherer groups such as indigenous first-nation Americans (e.g., Osborn, 1915; Bordes, 1950, 1969). It should also be remembered that the Palaeolithic record has not accumulated steadily through the vast swathes of Pleistocene time, but represents evidence from momentary episodes, interspersed with invisible hiatuses that represent the vast majority of that timespan. What might appear as sudden and drastic technological changes, more-likely represent the telescoped evidence of incremental change over many thousands of years. Thus, rather than invoke an Acheulian invasion to account for the appearance in Britain of handaxe-based industrial traditions later in the Hoxnian (e.g., Ashton et al., 2016), it is more parsimonious, and also more compatible with a realistic understanding of the nature of the Middle Pleistocene archaeological record, to regard this change as representing in situ technological development of the British population - who it should also be remembered were now for the first time cut off on an island from mainland continental Europe (Preece, 1995). And likewise in other parts of the world, we should be wary about a simplistic reversion to culture-historical explanations of synchronous and diachronic material cultural variability, without proper consideration of alternative explanations that take account of the multiplicity of behavioural and contextual factors than can influence material cultural deposition, and without better consideration of the distorting effect of the time-dilated nature of the deep archaeological record.

A contingent question then becomes to consider why did the lithic industrial tradition that sufficed during the initial post-Anglian colonisation of Britain undergo this change. And beyond that, what factors drive lithic technological change through the Palaeolithic across the globe, once one thinks beyond a shallow tribal and culture-historical narrative focusing on the strip of the away team (Gamble, 1986: p. 15). These are not questions that will be addressed in the remainder of this paper, although the ecological framework discussed is without doubt pertinent to them. However, briefly, I suggest that lithic technological practices should be seen as locally-specific solutions to perennial problems of resource distribution —embracing lithic raw materials, other raw materials, animal resources, and plant resources - and adaptive strategy— embracing mobility, demography and technology. Thus, there is potential for high degrees of convergent and repetitive technological evolution through the Palaeolithic. For instance, it seems unnecessary (as well as unconvincing) to invoke continuity of a culturally-transmitted "Acheulian" industrial tradition to explain the connection between a handaxe-making instance in Lower Pleistocene Africa and one in India, or between an instance in the Somme valley of northern France in MIS 15 and one in southern Britain 200,000 years later in later MIS 11. Rather, it seems reasonable to see handaxe development as a recurring solution to a particular set of problems posed for Middle Pleistocene hominin groups living in environments with a certain structure of constraints and potentialities. And likewise, one can equally see that handaxe-making, which is a more difficult technical skill than flake production, may fade away in certain circumstances if a hominin adaptation can flourish without it —as for instance exemplified in the Middle Pleistocene record at Notachirico (Italy), where there appears to be recurring oscillation between horizons with handaxe manufacture and those without (Piperno et al., 1998; Piperno and Tagliacozzo, 2001). In fact, considering the efficacy of a simple unworked flake as a cutting tool, one of the key hitherto-unasked questions of the Palaeolithic has to be: "why did they ever bother with handaxe-making?", which is not only technically much more difficult, but requires more-carefully-chosen raw material, more-specific and harder-to-source tools such as a soft bone/antler percussor, and, after all that effort, produces a tool with a less acute cutting edge.

In relation to the Ebbsfleet elephant site and the transition from "Clactonian" flake/core lithic industrial traditions to "Acheulian" handaxe-dominated traditions through the Hoxnian in the UK, I have argued (Wenban-Smith, 1998, 2013c) that this may relate to changing patterns of mobility and resource exploitation in relation to the changing availability of lithic raw material through an interglacial period. However, the intention of this contribution is to look beyond this type of site-specific, culture-historical and regionally-contextual interpretation, valuable parts of the subject discourse though these are. Rather, I wish to situate the Ebbsfleet elephant discovery within a wider ecological framework, and to explore the importance, and implications, of megaherbivore exploitation —and in particular elephant exploitation— for Middle Pleistocene hominin adaptations in northwest Europe.

5.3 ECOLOGICAL FRAMEWORK FOR PLEISTOCENE ADAPTATIONS

5.3.1. SOME UNDERLYING PRINCIPLES

Ecology involves understanding the web of interactions between living organisms that allow them to persist in a sustainable manner. The interactions between living organisms are in a constant state of dynamic flux, as they eat each other, compete for resources, and evolve to survive and procreate better. The earth has some fundamental physical parameters that constrain and influence the adaptations of various species. In particular, there is the annual seasonal cycle whereby varying day-length affects the amount of solar radiation received, latitude that affects the angle of the sun's radiation and thus its intensity, and macro-regional factors such as the continentality or the degree of maritime influence. These parameters define the plant growing season and productivity in different parts of the globe, leading to regionally and latitudinally distinctive biomass structure, encompassing primary plant growth, and higher trophic levels of secondary and tertiary animal consumption.

As summarized by numerous authors (e.g., Geist, 1978; Gamble, 1986; Roebroeks, 2001), increasing seasonality in higher latitudes generally leads to simpler ecosystem structures, with lower diversity of plant and animal species. For moderately-high latitudes primary plant production includes trees and shrubs that lock a substantial amount of received energy into their physical structure, which then shuts down for the winter, and grasses that grow vigorously in the growing season, but which only retain a modest perennial root system and invest most of this energy into producing and dispersing seeds that lie dormant until the next growing season. At even higher latitudes, the constraints of the annual growing season mean that trees are not sustainable, and the primary plant biomass is predominantly grasses, with some shrubs. And at the highest latitudes (such as much of Antarctica), life has not yet evolved to be sustainable, so it is a barren waste of snow and ice. Herbivorous animal communities that are the primary consumers of the plant biomass, and then secondary and tertiary animal consumers, have likewise evolved various adaptations that show regional and latitudinal variation in conjunction with the fundamental patterning of primary plant production.

From the point of view of investigating early hominin adaptations, and the Middle Pleistocene spread of hominins into northwest Europe, this region was peripheral to the lower latitude tropical and sub-tropical core zone of hominin occupation in the late Pliocene and Early Pleistocene, where hominins filled an adaptive niche in ecosystems with higher animal diversity and less seasonality. Through the later Early Pleistocene and the early Middle Pleistocene there seems to have been a pattern of occasional hominin incursions into more northerly latitudes during warmer episodes (Dennell, 2003; Parfitt et al., 2005, 2010), interspersed with long periods of absence when they were unable to sustain a stable adaptation in the higher latitudes with the challenges of greater seasonality, harsher winters and the associated structuring of animal communities. As suggested by Dennell (ibid.) these early cycles of northward expansion and then local extinction most likely correspond with the expansion and contraction of the ecozone in which the earliest European hominins were adapted. It is suggested here —in fact echoing the suggestion of Geist (1978: pp. 281–282) as quoted by Roebroeks (2001: p 447)— that subsequent hominin success in this evolutionary environment, represented by further and more persistent northward settlement, would have been predicated on development of a new adaptation to a niche focused on megaherbivore exploitation. This would initially have been less-contested by other carnivores in the core inhabited zone, and then would also have been better-suited for sustainable survival in more-northerly latitudes, as outlined in more detail here below.

Two conjectures rooted in this ecological perspective are presented here. One (Conjecture 1) relates to hominin adaptation and range expansion in NW Europe during ameliorating and stable warm climate in MIS 11. And the other (Conjecture 2) relates to Neanderthal range persistence in NW Europe during the Last Glacial, and how this was destabilised by the influx of anatomically humans relying on the same niche in more-northerly areas, but exploiting it more intensively and unsustainably, leading to the local demise of Neanderthals.

5.3.2. CONJECTURE 1: RANGE EXPANSION DURING CLIMATIC AMELIORATION AND STABILITY

Hominins initially evolved in the late Pliocene in tropical and sub-tropical Africa, most-likely filling a marginal scavenging niche against a backdrop of low seasonality and high biological diversity. The plant and animal communities would have had a substantially longer background of co-evolution, so the hominins would have had to find a niche, and then develop new niches, within a context of pre-existing plant/animal adaptations, who had already long been engaged in their own evolutionary arms race. In this context mega-herbivores - such as elephants and rhinoceros —can be construed as "apex herbivores", with their size and other defenses rendering them immune to carnivore predation, unless weak or injured, or juvenile and undefended. Once an early hominin adaptation had appeared it could easily spread throughout similar ecozones, although it— along with all interacting elements of the ecosystem - would also have been undergoing a continuous evolutionary process of challenge and development that would lead to persistence and range expansion of the hominin population when successful, but local extinction when not.

A fundamental characteristic of biomass productivity is that the plant growing season becomes shorter and more intense with increased latitude, and the animal communities of higher latitudes are less diverse, although often more-structured into size groups and with each group often very abundant. The herbivore communities have a variety of strategies to sustain their adaptation, with varying degrees of mobility to follow resource opportunity, seasonal fattening-up to withstand the relative paucity of plant resource, and exploitation where feasible of winter plant resources such as tubers. And then the carnivore communities map onto the distribution and adaptations of the herbivores. Although vagaries of elevation and continentality mean that ecozones do not move in a straightforward away in conjunction with Pleistocene climatic change, there is nonetheless a general trend for ecozones characteristic of lower latitudes to expand and spread northward during phases of climatic amelioration, and then to reduce and contract southward during phases of climatic deterioration.

When one considers the nutritional requirements of Pleistocene hominins, it is clear that (without intricate and labour-intensive exploitation strategies, and without carefully-targeted acquisition of certain key nutrients that are often scarce or absent other than from an animal source) these need to be met by the exploitation of animal resources (Gamble, 1986: pp. 97– 103). Gamble suggested that the most-suitable niche for hominin exploitation, particularly in the predominantly-open environments of the mid-latitudes of western Europe, would be to compete with carnivores for medium-sized herbivores such as *Bos/Bison*, horse and various deer. Despite the amount of nu-

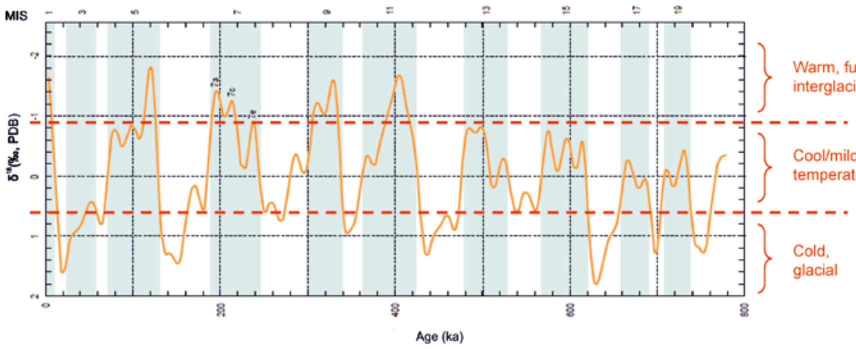

Figure 5.6. Global marine isotope stage (MIS) framework of Pleistocene climatic variations [adapted from Wenban-Smith et al. (2020: fig. 16.3), with permission of Oxford Archaeology and High Speed 1, using SPECMAP stacked data from Imbrie et al., 1984].

trition recoverable from a single individual, he regarded the largest herbivores such as elephant and rhinoceros as too difficult to kill and perhaps also unsustainable as the basis for an adaptation due to their low reproductive potential.

However, here (following Geist, ibid.) it is suggested that the largest herbivores would in fact have been the best resource upon which to base a hominin adaptation in this part of the world, if they could be harvested. Firstly, this would be a new niche, and thus successful exploitation would avoid a continual and draining conflict with other carnivores. Secondly, there is no reason to regard occasional exploitation of adult individuals as in any way threatening the sustainability of the prey resource. If one considers, for instance, the mobility and reproduction strategies of modern elephants in the open areas of Africa, they have a fission/fusion strategy whereby sub-adult and adult males roam singly or as fluid groups of various sizes. In contrast, herds of related females stay together for their full lifespan with juveniles of both genders, protecting them from predation, until the young males are evicted from the matriarchal herd as they approach adolescence and are able to fend for themselves, and having learnt the locations of key resources in their territory. Males and male groups then coalesce in the same locations as female herds for breeding, which habitually involves the bull males fighting for sexual access to a fertile female. A population of this nature would thus be highly resilient to the predation of adult males, and in fact could well produce a supply of injured or weakened males that could be more vulnerable to predation and wholly outside the breeding chain.

Once a hominin adaptation had developed that was successfully based upon a new niche involving the predation of adult megaherbivores, this would have great potential for the expansion of the hominin range northward into Europe, and during the more-temperate stages of the Pleistocene into the more-northerly western European latitudes where the ecosystem and growing season were so favorable for these animals. And in fact many finds are compatible with this suggestion, such as various early sites in the Middle East (Revadim Quarry —Rabinovich et al., 2012; Gesher Benot —Rabinovich and Biton, 2011), Italy (Notarchirico —Piperno and Tagliacozzo, 2001; Polledrara —Anzidei et al., 2012; Castel di Guido —Saccà, 2012), Spain (Áridos 1 and 2 —Yravedra et al., 2010; PRERESA —Yravedra et al., 2012), Greece (Marathousa 1 —Panagopoulou et al., 2018), Germany (Lehringen and Gröbern —Adam, 1951, Gaudzinski, 2004) and the UK (Ebbsfleet —Wenban-Smith, 2013a) where there is evidence of early hominin exploitation of *Palaeoloxodon*, at times and places compatible with being at the northern limit of the hominin range during warmer stages (Surovell et al., 2005), or refugia during stages of colder climate. This suggestion is further explored below (Section 4) with a brief review of the archaeological record of northern France and southern Britain during the warm climate stage MIS 11, which followed the Anglian cold stage MIS 12, this latter being the most severe cold stage of the Middle

Pleistocene (Fig. 6), with the most prolonged duration of cold conditions and the greatest spread of glacial ice.

5.3.3. CONJECTURE 2: RANGE PERSISTENCE DURING CLIMATIC DETERIORATION

The big picture of Pleistocene climatic change (Fig. 6) provides a saw-tooth curve, whereby major ameliorations happened very rapidly, but deterioration was a more gradual affair. Thus, episodes of amelioration would have provided a wild (north) west scenario, with numerous species extending their adaptations into expanding areas of newly-available terrain. This might in time have led to the new adaptations, but it would initially probably have involved the expansion of the same adaptations into the new terrain, with persistence of existing niches. In contrast, when climate deteriorated, this would have involved a reduction of terrain suitable for the prevailing adaptations. The relatively slow rate of climatic change would have facilitated some adjustment to the more-northerly adaptations. Thus, climatic deterioration need not have led to range reduction if a new adaptation could be achieved. However, changing climate and range reduction for a particular adaptation would have provided evolutionary stress that would have led to local extinction if successful change could not be achieved.

It would not only have been hominin adaptations that would have been subject to these evolutionary stresses, but also the adaptations of the herbivores upon which the hominins depended. The climatic oscillations of the Pleistocene are ultimately driven by orbital factors that dictate the amount and intensity of solar radiation reaching the earth. Thus cold-climate stages are intrinsically associated with reduced growing seasons in more-northerly latitudes. For a particular latitude, the plant biomass would have had a deterioration in the proportion of shrubs/trees and an increase in grasses, which would have had a shorter but intense growing season. The response of the herbivore community to this would have been for an increased proportion of the animal biomass to become locked up in larger herbivore herds, and herds of larger herbivores; and the more challenging conditions became in terms of reduced growing season, the greater the adaptive pressure for increased herbivore size. Therefore, for the sub-arctic steppe and tundra that would have developed in northwest Europe during cold glacial episodes, the predominant animal biomass would have been herds of mammoth. For hominins at the northern end of their range, their northerly persistence would therefore become tied up with the extent to which they were able to exploit large herbivores; and the larger the herbivores they were able to exploit, the more northerly their adaptation could persist as climate deteriorated. Thus, it is argued here that, following from a hominin adaptation that was already based upon herbivores and megaherbivores when climate was temperate but cooling, their ability to exploit megaherbivores would have been the key determinant of how far north an adaptation could persist during colder and glacial climatic phases. And if they were to persist in northwest Europe during cold glacial episodes, they would have had to be able to exploit a mammoth-based niche. This conjecture is explored below (Section 5), in relation to the evidence for the Neanderthal occupation of northwest Europe in the earlier Devensian glaciation, and the replacement of the Neanderthals by anatomically modern humans in the later part of this glaciation.

5.4 HOMININ RANGE EXPANSION AND SUSTAINABLE ELEPHANT EXPLOITATION IN NORTHWEST EUROPE IN MIS 11

In this section I briefly review some of the data that we have for *Palaeoloxodon* presence in NW Europe before and during MIS 11, and how our data relate to hominin presence and (on occasion) elephant exploitation. While one can rarely provide positive proof of any idea about the Palaeolithic, one can at least explore the data for falsification. And if no falsifying data can be found, and if an idea is compatible with observations and theoretical perspectives based on the present day, then we can at least go forward with an idea as "not yet ruled out, and compatible with known information".

Palaeoloxodon was clearly a common element of the fauna of this region both before and after the Anglian glaciation, and likely to have been coeval with the northernmost extent of the hominin range during the Anglian glaciation. The species is present (alongside other elephantid taxa) in Terrace VII (Renancourt) of the Somme at Abbeville, attributed to MIS 16/15 (Tuffreau and Antoine, 1995), although here the contemporaneity of hominin presence is uncertain. It is also present in the southern UK sites of High Lodge (Stuart, 1992), Ostend (Roberts and Parfitt, 1999: p. 304) and (although only as a fragmentary pieces attributable to "elephantid") at Boxgrove (Roberts and Parfitt, 1999: p. 226), attributed to the intra-Anglian interstadial of MIS 13; here, there is no doubt over the contemporaneity of hominin presence in the UK with *Palaeoloxodon* in MIS 13, although there isn't direct evidence of hominin exploitation.

After the Anglian, there are relatively numerous sites with *Palaeoloxodon antiquus* remains from MIS 11. In southwest France *Palaeoloxodon* is an abundant element of the Argiles du Gurp Formation in the Médoc, attributed to MIS 11 (Beauval et al., 1998; Bosq et al., 2019). In the Somme valley in northern France, there is abundant evidence for the presence of *Palaeoloxodon* contemporary with hominin presence in MIS 11 in Terrace V, Cagny/Garenne (Commont, 1908; Tuffreau and Antoine, 1995). In the UK, there is good evidence in particular from Clacton-on-Sea (Wymer, 1985: pp. 264–284), where abundant remains of *Palaeoloxodon* and hominin presence have been recovered from deposits that date from the late Anglian through to the Late Temperate zone of the Hoxnian, with the lowest and richest horizon even being named "the elephant bed" in light of the abundant presence of *Palaeoloxodon*. Other UK sites where *Palaeoloxodon* is present in MIS 11 alongside hominins are Barnham (Parfitt, 1998), Barnfield Pit in Swanscombe (Conway et al., 1996), Hoxne (Stuart et al., 1993: p. 170) and of course the Ebbsfleet elephant (Section 2). At Barnham, Barnfield Pit and Southfleet Road there is evidence of Clactonian lithic industry in stratigraphically lower horizons contemporary with the *Palaeoloxodon* remains, and attributable to the early temperate zone of MIS 11; and at the latter site there is also, as reviewed above, solid evidence of direct hominin exploitation of an adult elephant. At Barnfield Pit, the only of these sites with deeper stratigraphy preserving both lithic and faunal remains, there is continuing presence of *Palaeoloxodon* (Sutcliffe, 1964; Stuart, 1982) in phase II of the site sequence —the Middle Gravels, see Table 2— alongside lithic artifacts reflecting hominin presence, although the lithic industry of these higher horizons is dominated by handaxe manufacture in contrast to the Clactonian industry of the Phase I levels (Wymer, 1968: pp. 334–343; Ashton and McNabb, 1996). And tusks and molars of *Palaeoloxodon* have regularly been found from other sites in the Swanscombe area where the Phase II deposits have been investigated, such as at the Swan Valley School (Wenban-Smith and Bridgland, 2001). At Hoxne, the horizons that have produced both lithic artifacts and elephant remains are thought to relate to a short reversion to temperate conditions in MIS 11a at the end of the Hoxnian (Ashton et al., 2008), post-dating the Phase II deposits of the Swanscombe sequence.

The overall picture from these data is that *Palaeoloxodon* was present in northwest Europe during more-temperate climate stages between MIS 16 and MIS 10, broadly coeval throughout this period with hominins. The evidence of hominin presence before MIS 12 is sporadic, and there is no direct evidence of hominin exploitation of elephants, although of course this absence of direct evidence cannot be taken as evidence that this did not occur. There seems to have been a marked uptick in the intensity of Palaeolithic occupation in this NW European region in MIS 11 after the Anglian glaciation. Not only are there very numerous sites demonstrating hominin presence from across southern England and northern France, but there are also quite a few sites that show co-occurrence of hominin activity and elephant presence, notably the specific instance of elephant exploitation at Southfleet Road, early in MIS 11. Importantly, despite the clear-cut evidence for hominin contemporaneity with, and exploitation of, elephant in the early Hoxnian, this does not seem to have affected the continuing presence of elephant through the rest of the Hoxnian (sensu MIS 11c) or in the final stages of the Hoxnian as represented at Hoxne itself (MIS 11a), a period spanning maybe 50,000 years (Table 2). Furthermore, despite the general rarity of well-provenanced elephant fossils from northwestern Europe in MIS 11-10 (comprising France, Belgium, Netherlands and UK), the record from Soulac (Gironde) in SW France provides firm evidence that the abundant presence of hominins in this region at this time did not lead to the local extinction of *Palaeoloxodon*. Taken together, these data support the notion that, contra Surovell et al. (2005), the observed pattern of proboscidean exploitation sites across the Pleistocene Old World reflects the importance for pioneer hominin adaptations of sustainable elephant exploitation, rather than being a harbinger of their doom.

5.5 LAST GLACIAL ADAPTATIONS IN NORTHWEST EUROPE AND NEANDERTHAL EXTINCTION

We have a much better understanding of the overall pattern of the data for this later period (e.g., Mellars and Stringer, 1989; Mellars, 1990, 2004; Akazawa et al., 1998; Klein, 2003; Harvati, 2012; Zilhao, 2014). However, this does not seem to have led to a consensus view, but rather to an increased multiplicity of suggestions to explain the demise of the Neanderthals (Soffer, 1994; Mellars, 2004; van Andel and Davies, 2003; Stewart, 2005; Kuhn and Stiner, 2006; Golovanova et al., 2010; Houldcroft and Underdown, 2016; Ko, 2016; Degioanni et al., 2019). The generally-accepted data pattern is that Neanderthals were successfully occupying much of the territory of northwest Europe through much of the period MIS 8–4. The extent to which their often-supposed southwest France heartland is an artifact of 19th–20th century investigation and interpretation is uncertain, but this was without doubt an area of persistent occupation (Bordes, 1972), and probably a refugium in the coldest parts of this stretch of time. There are also good records of Neanderthals themselves, or of their lithic artifactual remains, from much further north, in northern France (e.g., La Chaise —Condemi, 2001; Biache St Vaast —Guipert et al., 2010; Tourville-la-Rivière —Faivre et al., 2014; Caours —Antoine et al., 2006, and see Locht et al., 2016 for a general review of Middle Palaeolithic sites), Belgium (Spy, Engis and La Naulette —Fernández-Jalvo and Andrews, 2019), the Channel Islands (Callow and Cornford, 1986; Bates et al., 2013; Scott et al., 2014), the Netherlands (Maastricht-Belvedere —Roebroeks et al., 1992b) and even the UK (White and Jacobi, 2002; Harnham —Bates et al., 2014; Dartford —Wenban-Smith et al., 2010; and Lynford —Boismier et al., 2012).

Although the pattern of occupation may be distorted by its focus on the more-visible cave and rock-shelter sites, there are also several open-sir sites (such as Harnham, Biache-Saint-Vaast, Maastricht-Belvedere, Tourville-La-Rivière, Caours, Dartford and Lynford). More-northerly occupational evidence seems intermittent in the period MIS 8–6 (Roebroeks and Tuffreau, 1999; Roebroeks et al., 2011), and also, curiously, in the warm interglacial conditions of MIS 5e, the reason for which there has been much debate (Gamble, 1986; Roebroeks et al., 1992; Roebroeks and Speleers, 2002). Bearing in mind the dating imprecision of most sites from this period, La Cotte de St Brelade, on Jersey, is perhaps a good representative example of northerly occupation by Neanderthals in this period, with numerous superimposed occupational levels that attest episodic presence from MIS 7 through to the Last (Devensian) Glacial (Bates et al., 2013; Scott et al., 2014). The main occupation horizons date to within MIS 7, and there is interesting evidence of two "bone heaps" —a "lower" heap in the bottom part of layer 3, and an "upper" heap in the bottom part of layer 6. These bone heaps— which are dominated by bones of mammoth and rhino - abut, and partly merge into, the underlying occupation horizons: layers A and 5 respectively. Both bone heaps are covered by loessic deposits without evidence of human activity that are thought to represent cold climate, and too cold for hominin survival here, perhaps a stadial within MIS 7 for the lower loess bed, followed by layer 6 representing loess accumulation in MIS 6. Towards the end of MIS 6, pulses of climatic warmth coincided with the northward expansion of Neanderthals (van Andel et al., 2003), and their re-settlement in northern Europe, at the site of Veldwezelt-Hezerwater in Belgium (Bringmans, 2007). There are, however, indications of presence in MIS 6 in Biache-Saint-Vaast, and in Beavais (La Justice) (Roebroeks and Tuffreau, 1999). Later, there is evidence of Neanderthal presence near the Normandy coast during MIS 5e, at the site of Caours in the lower Somme valley (Antoine et al., 2006). The evidence suggests that, although Neanderthals did have some adaptations to cold climate, they did not necessarily prefer it, and their population increases and northward range expansions corresponded with episodes of relative climatic warmth (van Andel et al., 2003; Hublin and Roebroeks, 2009; Locht et al., 2016), although still by no means fully temperate. Once they arrive this far north in MIS 5, there are relatively numerous sites in northern France from the post-Eemian cooler periods MIS 5d–5a, representing the early part of the Devensian glaciation (Antoine, 1993; Vallin and Masson, 2004; Bringmans, 2007; Locht et al., 2016). And there is also one site in southern England from this period, near Dartford (Wenban-Smith et al., 2010), suggesting that the Neanderthal range occasionally extended into the UK, when the barrier of the channel area could be crossed, which, when not marine, would have been marshy badlands with a major river along its main axis. Later in the Devensian, towards the end of MIS 4 and in MIS 3, there is further evidence of increasingly abundant Neanderthal occupation in northern Europe and southern UK, at sites such as Spy and Goyet caves in Belgium (Wißing et al., 2019), Arcy-sur-cure in France (Leroi-Gourhan and Leroi-Gourhan, 1964; Higham et al., 2010) and Lynford Quarry in England (Boismier et al., 2012). And then there is consistent evidence that this thriving adaptation was suddenly interrupted c. 40,000–35,000 BP, and replaced by anatomically humans, often in the same sequence as at most of these afore-mentioned sites (the exception being Lynford, where the only evidence is from the Neanderthal era).

The focus of this section is not, however, to provide a comprehensive review of the evidence, but to float a speculative idea on the eventual demise of the Neanderthals in the later part of the Last Glacial, rooted in the preceding ecological discussion (Section 3) but also supported by recent data. In accordance with the ecological basis of this northerly Neanderthal adaptation, numerous analyses of Neanderthal diet (e.g., Stiner, 1994; Villa, 2009; Gaudzinski-Windheuser and Niven, 2009; Bocherens, 2009, 2011; Macdonald et al., 2009; Richards and Trinkaus, 2009) demonstrate a major reliance upon nutritious herbivores, with significant skeletal representation of mammoth and rhino bones, as well as other herbivores such as horse, bovid and deer. Although there is often spirited debate on the precise nature of human-mammoth interactions, probably with a general tendency to see the evidence as reflecting hunting rather than otherwise —e.g., for Lynford Quarry, compare the analysis of Smith (2012) with that in the main volume (Schreve et al., 2012)— there is no doubting the importance of mammoths, and important recent and new evidence for this was presented, or referenced, at the Symposium (Wißing et al., 2016, 2019; Jaouen et al., 2019).

My own presentation suggested that the importance of mammoths for a sustainable northerly Neanderthal adaptation might have gone beyond their nutritional value, and that their spongey fat-rich bones might, especially in relatively treeless landscapes, have been an important source of fuel for fires, which would have been a key technology for sustaining adaptations in a cold climate. I thus drew attention to the published data from La Cotte (Callow and Cornford, 1986; Callow et al., 1986) which showed a significant presence of charred and intensely-heated scraps of mammoth bone in the main occupational layers A and 5, and suggested that the abutting and immediately-overlying mammoth bone heaps could perhaps be understood as associated stashes of "firewood" ready and waiting. Although they date earlier than the Last Glacial, they nonetheless may represent another, non-dietary, aspect of the importance of the mammoth for northerly Neanderthal adaptation in cold climatic periods. As identified by Callow et al. (ibid.) burnt bone fragments occur frequently throughout the occupational sequence, and especially in the associated layers A and 5, and are clearly interpretable as having been deliberately burnt, rather than cooked. The blue-white color of many of the burnt bone fragments reflects a high combustion temperature, as would be expected given the spongey structure and high fat content of mammoth limb-bone. This could therefore, have been a vital survival resource in cold landscapes without abundant trees. Of course other possibilities abound, as put forward during the meeting.

The importance of mammoth exploitation for both late Neanderthals and early modern humans is further highlighted by other recent work. Wojtal et al. (2019) demonstrated the smoking gun —or perhaps "quivering spear"— for modern human mammoth hunting, with evidence of a flint point embedded in a mammoth rib. Evidence from faunal remains and stable isotope analysis (Wißing et al., 2016, 2019) also shows the importance of mammoth year-round for Neanderthals and modern humans - in particular of tender, fatty and nutritious baby mammoths which must have been a sought-after treat. Bocherens and Drucker (this volume) review further isotope analyses that demonstrates the predominance of mammoth meat in the diet of both modern humans and Neanderthals, and also that for modern humans it was even greater. They drew attention to the potential ecological impact of this hyper-exploitation of mammoths by the earlier modern human colonizers of central and northwest Europe. As also suggested by Wojtal et al. (2019), these authors propose that the intensity of their exploitation may have been sufficient to challenge the sustainability of the mammoth populations, and that it may have affected the wider herbivorous niche structure and provided a dietary subsidy to other carnivores. They did not however, consider the impact upon pre-existing Neanderthal adaptations of the sudden arrival of a direct and unsustainably-successful competitor for the mega-herbivore exploitation niche. Likewise, Wißing et al. (2019) concluded that since Neanderthals and modern humans were eating the same thing, dietary differences could not explain Neanderthal extinction. However, it could be argued that it was precisely this dietary similarity that caused extinction, rather than any difference. As argued above (Section 3), the nutritional resource vital for Neanderthal survival would have been increasingly held in megaherbivore —and especially mammoth— herds as climate deteriorated, so the northerly limit of a Neanderthal adaptation could have been defined by their ability to exploit this megaherbivore resource. And thus when a direct competitor appeared who was (a) exploiting the same resource more intensely and (b) also perhaps significantly reducing the presence of mammoth overall, then the Neanderthal adaptation in northwest Europe may have become unsustainable, leading to their local extinction.

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6. ELEPHANTS AND HUMANS IN IBERIA: A ZOOARCHAEOLOGICAL APPROACH

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ABSTRACT

Proboscidean remains in Iberian Pleistocene sites were first discovered many centuries ago. Some of them were recovered together with lithic tools, leading researchers to associate them with human activities. However, in recent decades, several taphonomic works have provided new perspectives based on more precise methods and analyses. Elephant skeletal remains are common in open-air sites, where they appear in anatomical or semi-anatomical connections. This is the case in the Early Pleistocene sites of Orce (Granada) and La Boella (Tarragona); the Middle Pleistocene sites of Torralba and Ambrona (Soria), Áridos (Madrid) and Solana del Zamborino (Granada); and the early Late Pleistocene sites of the Manzanares terraces (Madrid). Nevertheless, several caves also show isolated remains of these very large animals, which are sometimes difficult to explain from a taphonomic point of view. Most of them appear in assemblages where anthropogenic activities were dominant, such as the case of Bolomor Cave (Valencia) during the Middle Pleistocene or the Abric Romaní and Teixoneres Caves (Barcelona) at the end of the Middle Palaeolithic. This study reviews the best-known cases with a special focus on the evolution of the relationship between elephants and humans in this specific geographic area.

6.1 INTRODUCTION

The energetic and nutritional value that elephant carcasses could provide for prehistoric human groups has always attracted the interest of archaeologists (e.g., Ben-Dor et al., 2011). This interest has been increasing progressively as more archaeological sites with remains of these animals have been discovered; this is particularly the case where the carcasses were presumably associated with anthropogenic artifacts. Currently, these localities can

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be found all over the world and are framed within nearly all prehistoric periods, which generate a transversal and interdisciplinary issue. Scholars have known about these sites since the beginning of Prehistory research. Almost all of them are located in fluvio-lacustrine contexts where one or more elephants were found (Arribas, 2004; Sala, 2014). Following the main contemporary paradigms, researchers interpreted the accumulations of elephant bones as a product of anthropogenic traps or sophisticated hunting strategies (e.g., Obermaier, 1925). However, the 1970s paradigms that critiqued the effectiveness and regularity of hunting skills among humans before the Upper Palaeolithic called into question many of the preceding interpretations and forced researchers to look into evidence more in line with the modern scientific methods that were being developed. For example, Shipman and Rose (1983) examined the proboscidean remains from Torralba and Ambrona (Soria, Spain), two Middle Pleistocene sites traditionally considered one of the best examples of elephant kill/butchering sites. These researchers were looking for direct evidence of the relationship between those carcasses and the human activities, mainly cut marks. However, they only observed a low frequency of anthropogenic damage on bones at both sites (~1%), which mainly involved other ungulates, such as deer and horses. From this work, the contact between hominins and elephants at these sites seemed to be infrequent and was probably related to occasional scavenging activities. This study showed the ambiguity that this type of assemblage usually entails and the difficulty in making correct interpretations from a modern perspective. Therefore, a new approach in the research of Pleistocene human–elephant interactions was introduced and required the completion of accurate multidisciplinary studies before achieving definitive conclusions (Haynes, 1991). The Torralba and Ambrona localities, however, are not unique cases in the Iberian Peninsula; there are many other sites that can contribute to our understanding of this issue in the different periods. Most of them are open-air places linked to ancient watercourses or palaeolakes. Nevertheless, isolated elephant bones (or anatomic portions) are also retrieved in karstic contexts, suggesting different dynamics. This study compiles all evidence of human–elephant interaction on the Iberian Peninsula while analyzing the significance of these megaherbivores for the human communities of the past. With this objective, we have revisited the main Iberian sites, where the human use of elephant carcasses was suggested. Only assemblages with clear human presence and stratigraphic and chronological control are considered.

6.2 ELEPHANTS IN IBERIA DURING THE PLEISTOCENE

The Iberian Peninsula has specific orographic characteristics that result in a great diversity of climatic and ecological environments (Floristán, 1990; Martín and Olcina, 2001). Iberia can be considered geomorphologically as the emerged part of an ancient tectonic plate (see Vera Torres, 2004). During the Alpine Orogeny, this plate moved progressively northward due to the pressure exerted from the south by the African plate. This process provoked the clash with the Eurasian plate and the formation of several structural deformations. The most important of these was the formation of several mountain ranges, such as the Pyrenees in the north and the Baetic System in the south. Similarly, a subduction zone was generated in the Gibraltar Strait, which separated Africa from Europe and had several influences on the contact between the Atlantic Ocean and the Mediterranean Sea. Nowadays, the Peninsula shows a large plateau slightly tilted to the west with an average elevation of 600 m a.s.l. and surrounded by rocky and steep coasts in the north, northeast and southeast, and softer coastlines to the southwest and west. This geomorphological unit is connected to the continent by the isthmus formed at the north between the Gulf of Lion in the Mediterranean Sea and the Bay of Biscay in the Cantabrian Sea. This portion of land is fully occupied by the Pyrenees, whose maximum elevation exceeds 3000 m a.s.l. and represents an

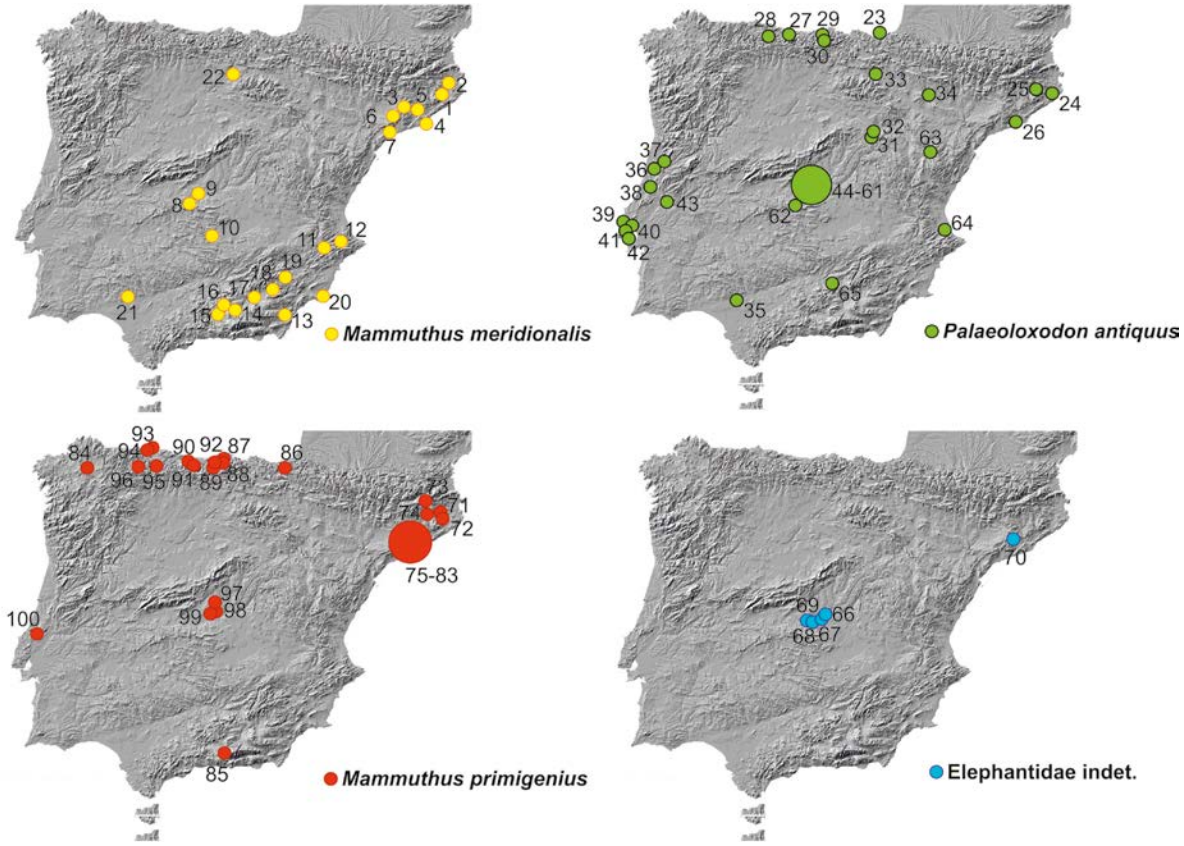

Figure 6.1: Location of the main Iberian archaeological sites with proboscidean specimens. The numbers correspond to the localities listed in Tables 6.1–6.4.

important natural border with the rest of the European continent.

Much of the Peninsula is influenced climatically by the Mediterranean Sea, except for the north and northwest, which are dominated by the Oceanic or Atlantic climate. However, this Mediterranean climate has important nuances depending on the geographical situation. For example, the Central Plateau corresponds to a degraded Mediterranean climate that, in many respects, is like a variety of the Continental Climate. The Alpine Climate can also be found in the main mountain ranges, such as in the Central Pyrenees and some areas of the Cantabrian Mountains, the Central System and the Baetic System. On the other hand, the most southeastern area is affected by important African influences —including aridity— and, in many respects, can be considered a semi-desert climate.

In the past, these topographic and climatic characteristics produced several periods in which Iberia was relatively isolated. It was always difficult for the terrestrial biological entities to cross the Gibraltar Strait, and there is not enough conclusive evidence to suggest that this occurred regularly. On the other hand, the Pyrenees played a role as a virtually impassable barrier, mainly at the east. However, the Cantabrian coast seems to have been most permeable, probably because of the lower elevations of the Western Pyrenees and the climatic similarities with the French Atlantic coast. In this respect, Iberia (and the other peninsulas in the south of Europe) could represent important refuge for many temperate taxa, including large mammals, during the cold periods. Elephants were relatively abundant in this highly diversified ecological context (Fig. 6.1, Tables 6.1–6.4). *Mammuthus meridionalis* was present during the Early

Pleistocene until the early Middle Pleistocene. Several sites show the broad dispersion of this species along the eastern coast (Incarcal in Girona and Molí Serelles in Alicante), the South Sub-Plateau (Valdelobos in Toledo, Fuensanta del Jucar in Ciudad Real and the Guadix-Baza Basin in Granada) and the North-Plateau (Gran Dolina of Atapuerca, Burgos) (Aguirre, 1989; Arribas, 2004; Ros-Montoya, 2010). However, there are not many detailed reports on *Mammuthus trogontherii* in Iberia. Controversial remains of this species have been documented in the early Middle Pleistocene terraces of the Anoia River (Capellades, Barcelona) and in Buenavista (Toledo) —a revision of these fossils is necessary as they could correspond to advanced forms of *Mammuthus meridionalis*. The Middle Pleistocene was the period in which *Palaeoloxodon antiquus* existed, mainly during the interstadials and elephant carcasses recovered from many sites, the most famous of which were the Torralba and Ambrona localities (Soria). On the contrary, the Late Pleistocene represented a critical period for the Iberian proboscideans: *Palaeoloxodon antiquus* disappeared at the end of the marine isotope stage (MIS) 3 (Antunes and Cardoso, 1992; Stuart, 2005), and the only taxon that remained in Europe was *Mammuthus primigenius*, which is usually associated with cold environments. Although there are some accounts of this species in Iberia, most of them are located in the Cantabrian region,

No.	Site	Location	Chronology	Type	Group	Lithics	Anthr	References
1	Bòbila Ordis	Girona	MIS 19-15	OA	1			Galobart et al., 1996
2	Incarcal	Girona	EP	C	1			Galobart et al., 1996
3	Cardener's Terraces	Barcelona	EP	OA	1			Aguirre, 1989
4	Sarrià	Barcelona	EP	OA	1			Aguirre, 1989
5	Cal Guardiola and Vallparadís	Barcelona	MIS 21-19	OA	1	ODW		Martínez et al., 2010; Palombo, 2014
6	Capellades	Barcelona	MIS 19-15	OA	1			Arribas, 2004
7	Barranc de la Boella	Tarragona	MIS 21-19	OA	2(?)	E-ACH	cm(?)	Vallverdú et al., 2014; Mosquera et al., 2015
8	Valdelobos	Toledo	MIS 19-15	OA	1			Arribas, 2004; Silva et al., 2017
9	Buenavista	Toledo	MIS 19-15	OA	1			Arribas, 2004
10	Valverde de Calatrava	Ciudad Real	EP	OA	1			Arribas, 2004
11	Fuensanta del Jucar	Ciudad Real	MIS 19-15	OA	1			Arribas, 2004
12	Molí Serelles	Alicante	EP	OA	1			Arribas, 2004
13	Cuevas de Vera	Almería	EP	OA	1			Arribas, 2004
14	Albolote	Granada	EP	OA	1			Arribas, 2004
15	Lachar and Fuensanta	Granada	EP	OA	1			Aguirre, 1989
16	Pantano de Cubillas	Granada	EP	OA	1			Arribas, 2004
17	Guadix Bassin	Granada	EP	OA	1			Arribas, 2004
18	Baza Bassin (Orce)	Granada	EP	OA	2	ODW	spp	Espigares et al., 2013, 2019
19	Huéscar	Granada	EP	OA	1			Montoya-Ros et al., 2018
20	Cueva Victoria	Murcia	EP	C	1			Aguirre, 1989
21	Villanueva del Pítamo	Sevilla	MIS 19-15	OA	1			Aguirre, 1989
22	Gran Dolina	Burgos	MIS 21-19	C	1	ODW		Aguirre, 1999

Table 6.1: Iberian sites with *Mammuthus meridionalis* specimens and references. The location of the sites (numbers) in the Iberian Peninsula can be seen in Figure 6.1.

Abbreviations: EP (Early Pleistocene), MP (Middle Pleistocene), L-MP (late Middle Pleistocene), LP (Late Pleistocene), Unc (Uncertain), Cave (C), Open-air (OA), ODW (Oldowan), E-ACH (early Acheulean), ACH (Acheulean), MP (Middle Palaeolithic), AUR (Aurignacian), SOL (Solutrian), GRV (Gravetian), UNC (Unclassified), Anthropogenic evidence (anthr), ac (anthropogenic context), bd (burning damage), cm (cut marks), ivt (ivory tools), spp (spatial pattern).

No.	Site	Location	Chronology	Type	Group	Lithics	Anthr	References
23	Cantera de Txomiñenea	Guipúzcoa	Uncertain	OA	1			Altuna, 1971
24	Cau del Duc de Torroella	Girona	L-MP	C	1	MP		Estévez-Escalera, 1979
25	Mollet I and Mollet III	Girona	MIS 5	C	1	MP		Maroto and Soler, 1987; Galobart et al., 1996
26	Muscle Cave	Barcelona	MIS 5	C	1			Estévez-Escalera, 1979; Nadal, 2000
27	Dejesa Cave	Asturias	MP	C	1			Álvarez-Lao, 2003
28	Gafares Cave	Asturias	PM	C	1			Álvarez-Lao, 2003
29	El Castillo Cave (?)	Cantabria	MIS 3	C	3 (?)	AUR	ac	Arribas, 2004, Stuart, 2005
30	Tejera de Saron	Cantabria	MIS 5	OA	1			Castaños et al., 2012
31	Torralba	Soria	MIS 7	OA	1	ACH		Villa, 1990; Santonja et al., 2014a
32	Ambrona	Soria	MIS 9	OA	2	MP	cm, spp	Santonja and Pérez-González, 2006; Santonja et al., 2014a
33	Logroño's Terraces	La Rioja	MP	OA	1			Arribas, 2004
34	Villanueva de Gállego	Zaragoza	MP	OA	1			Arribas, 2004
35	Cantillana y Rinconada	Sevilla	MP	OA	1			Arribas, 2004
36	Mealhada	Coimbra	MIS 5	OA	1	ACH		Cardoso, 1993
37	Condeixa	Coimbra	MIS 11-9	OA	1			Cardoso, 1993
38	Meirinha	Leiria	MP	OA	1			Cardoso, 1993
39	Santa Cruz	Lisbon	MP	OA	1			Cardoso, 1993
40	Santo Antão do Tojal	Lisbon	MP	OA	1	UNC		Cardoso, 1993
41	Casal do Torquato	Lisbon	MIS 5	OA	1			Cardoso, 1993
42	Figueira Brava Cave	Algarve	MIS 3	C	3 (?)	MP	ac	Antunes and Cardoso, 1992; Cardoso, 1993; Zilhao et al., 2020
43	Foz do Enxarrique	Castelo Branco	MIS 3	OA	1	MP		Antunes and Cardoso, 1992
44	San Isidro	Madrid	MIS 6-5	OA	2 (?)	ACH		Santonja et al., 2014b; Rubio-Jara et al., 2016
45	Orcasitas	Madrid	MIS 6-5	OA	2 (?)	ACH		Santonja et al., 2014b; Rubio-Jara et al., 2016
46	Arenero de Rojas	Madrid	MIS 6-5	OA	2	MP	spp, ac	Santonja et al., 2014b
47	Transfesa/Tafesa	Madrid	MP	OA	2 (?)	ACH	spp	Baena et al., 2010; Santonja et al., 2014b; Rubio-Jara et al., 2016
48	Valdocarros	Madrid	MIS 9-7	OA	1	ACH		Yravedra and Domínguez-Rodrigo, 2009; Moreno et al., 2019
49	Arriaga IIa	Madrid	MIS 6	OA	2	ACH	spp	Santonja et al., 2014b; Panera et al., 2014
50	Áridos 1 and 2	Madrid	MIS 11	OA	2	ACH	cm, spp	Sesé and Soto, 2002; Yravedra et al., 2010
51	Arenero de Manuel Soto	Madrid	MIS 5	OA	1	UNC	spp, ac	Panera et al., 2014
52	Arenero de Los Llanos	Madrid	MIS 5	OA	1	ACH	spp, ac	Panera et al., 2014
53	Arenero de Santa Elena	Madrid	MIS 7-6	OA	2 (?)	ACH/MP	spp, ac	Panera et al., 2014; Rubio-Jara et al., 2016
54	Arenero de Pedro Jaro	Madrid	MIS 5	OA	1	UNC	spp, ac	Panera et al., 2014
55	Estanque de Tormentas	Madrid	MIS 6	OA	1	ACH	spp, ac	Silva et al., 2012; Panera et al., 2014
56	Arenero de Oxígeno	Madrid	MIS 7-6	OA	1	ACH	spp, ac	Panera et al., 2014; Rubio-Jara et al., 2016
57	Arenero de Quemadero	Madrid	MIS 5	OA	1	ACH	spp, ac	Panera et al., 2014
58	Arenero de los Hijos de Aguado	Madrid	MIS 5	OA	2 (?)	ACH	spp, ac	Panera et al., 2014
59	Fabrica de Ladrillos	Madrid	MIS 5	OA	2 (?)	ACH	spp, ac	Panera et al., 2014
60	Arenero del Arroyo Culebro	Madrid	MIS 5	OA	2 (?)	ACH	spp, ac	Panera et al., 2014
61	Arenero de Alcaraz	Madrid	MIS 5	OA	2 (?)	ACH	spp, ac	Panera et al., 2014
62	Pinedo	Toledo	MP	OA	1	ACH		Santonja et al., 2014b
63	Cuesta de la Bajada	Teruel	MIS 9-7	OA	3	MP	ac	Domínguez-Rodrigo et al., 2015
64	Bolomor Cave	Valencia	MIS 9-5	C	3	MP	cm, bd, ac	Blasco et al., 2013
65	Solana del Zamborino	Granada	MIS 13-9	OA	2	ACH	spp	Botella et al., 1975; Álvarez-Posada et al., 2017

Table 6.2: Iberian sites with *Palaeoloxodon antiquus* specimens and references. The location of the sites (numbers) in the Iberian Peninsula can be seen in Figure 6.1. For the abbrevations see Table 6.1.

No.	Site	Location	Chronology	Type	Group	Lithics	Anthr	References
66	PRERESA	Madrid	MIS 6/7	OA	2	MP	cm, spp, ac	Yravedra et al., 2012; Panera et al., 2014; Moreno et al., 2019
67	Arenero de Jesús Fernández	Madrid	Unc	OA	2	ACH	spp, ac	Panera et al., 2014
68	Arenero de Constantino del Río	Madrid	Unc	OA	2	ACH	spp, ac	Panera et al., 2014
69	Arenero de Los Pinos	Madrid	MIS 5	OA	2	ACH	spp, ac	Panera et al., 2014
70	Abric Romaní	Barcelona	MIS 3	C	3 (?)	MP	ac	Rosell et al., 2012

Table 6.3: Iberian sites with Elephantidae (indet.) specimens and references. The location of the sites (numbers) in the Iberian Peninsula can be seen in Figure 6.1. For the abbrevations see Table 6.1.

which shows the connection with the southwest of France throughout the MIS 3–2, and in Eastern Catalonia. However, woolly mammoth remains are rare in the rest of the Peninsula and are probably related to very cold climatic pulsations and some movement of these animals from the north of the Pyrenees. This is the case for Figueira Brava (Setúbal), Padul (Granada) and the terraces of the Manzanares River (Madrid; Arribas, 2004). Their presence during the MIS 2 is also recorded from the rock art, as can be seen in sites like El Pindal (Asturias), El Castillo (Cantabria), Los Casares (Guadalajara), Reguerillo Cave (Madrid) and Ojo Guareña (Burgos).

6.3 EARLY PLEISTOCENE

The human presence in the Iberian Peninsula is documented as far back as 1.4 Ma, as recorded at Fuente Nueva-3 and Barranco León (Orce, Guadix-Baza Basin, Granada; Toro-Moyano et al., 2013) (Fig. 6.2). Both sites contain archaeological assemblages in fluvio-lacustrine environments where lithic artifacts associated with a high diversity of ungulates were retrieved. The accumulations have been interpreted as the result of a natural trophic dynamic around a lacustrine or swampy landscape similar to those observed in Africa, both today and in the past (Espigares et al., 2013, this volume). According to Toro-Moyano et al. (2013), the important water accumulations were regularly visited by the herds of ungulates of the region, which, in turn, attracted a great diversity of predators. The main carnivores were hyenas (*Pachycrocuta brevirostris*), although wolves (*Canis mosbachensis*) and wild dogs (*Lycaon lycaonoides*), among others, were also present. Several human groups could have been taking advantage of the situation as well, which generated strong competition with other predators. Mammoth (*Mammuthus meridionalis*) fossils from Orce are relatively common, mainly at Fuente Nueva-3. Espigares et al. (2013, 2019, this volume) reported one of the most significant cases for the issue analyzed here. This site yielded a partial mammoth carcass in a thin bed of fine sands, which preserved the articulated rib cage and the pelvis, in addition to one scapula and mandible. Around the elephant, 17 flint flakes (Oldowan) and 34 coprolites were also recovered, suggesting activities of hominins and hyenas related to carcass processing or consumption. One of the main arguments used by the authors to make this association was the lack of limb bones. Espigares et al. (2013) propose that the assemblage is the result of a single event characterized by a rapid burial. The sand was deposited by low-energy water flows that could have produced slight movements of materials, but were not strong enough to make coprolites and lithic artifacts disappear. Therefore, the absence of limbs could be related to the ravaging activities of the predators or scavengers. Nevertheless, damage was not recognized on the mammoth bones, which makes it difficult to infer accurately when each predator had access to the carcass. The stratigraphic location of one coprolite under a rib is the only possible indication of hyena activities before the mammoth event. The authors propose

No.	Site	w	Chronology	Type	Group	Lithics	Anthr	References
71	Arbreda	Girona	MIS 4/3	C	3 (?)	MP	ac	Estévez-Escalera, 1979; Rufi et al., 2018
72	Cau de les Goges	Girona	MIS 2	C	3	SOL	ivt, ac	Estévez-Escalera, 1979; Daura et al., 2013
73	Vall de Bianya	Girona	LP	OA	1			Arribas, 2004
74	Clot del Llop	Girona	LP	C	1			Altuna, 1996; Álvarez-Lao and García, 2012
75	Fontrubí	Barcelona	MIS 3	OA	1			Arribas, 2004
76	Sant Vicenç dels Horts	Barcelona	LP	OA	1			Arribas, 2004
77	Congost River	Barcelona	LP	OA	1			Arribas, 2004
78	Vallformosa	Barcelona	LP	OA	1			Arribas, 2004
79	Arenys de Mar	Barcelona	LP	OA	1			Arribas, 2004
80	Teixoneres Cave	Barcelona	MIS 3	C	3 (?)		ac	Álvarez-Lao et al., 2017
81	Pedralbes	Barcelona	LP	OA	1			Altuna, 1996
82	Riera dels Canyars	Barcelona	MIS 4	OA	1			Daura et al., 2013
83	Riera de St. Llorenç	Barcelona	MIS 4	OA	1			Daura et al., 2010, 2013
84	Buján	Lugo	LP	C	1			Álvarez-Lao and García, 2012
85	Padul	Granada	MIS 3	OA	1			Álvarez-Lao et al., 2009; Álvarez-Lao and García, 2012
86	Labeko Koba	Guipuzkoa	MIS 3	C	3 (?)	AUR	ac	Altuna and Mariezkurrena, 2000; Álvarez-Lao and García, 2012
87	Minas de Heras	Cantabria	LP	C	1			Álvarez-Lao and García, 2012, Castaños et al., 2012
88	Cueva Morín	Cantabria	MIS 2	C	1	GRV	ac	Álvarez-Lao and García, 2012
89	Udías	Cantabria	LP	C	1			Álvarez-Lao and García, 2012
90	Mina Ángel	Cantabria	LP	C	1			Álvarez-Lao and García, 2012
91	Mina Inadvertida	Asturias	MIS 3	C	1			Domingo et al., 2005; Castaños et al., 2012
92	El Cierro	Asturias	MIS 2	C	3 (?)	SOL	ac	Álvarez-Lao and García, 2012
93	La Lloseta	Asturias	MIS 2	C	1			Álvarez-Lao and García, 2012
94	La Güelga	Asturias	MIS 3	C	1			Álvarez-Lao and García, 2012
95	Las Caldas	Asturias	MIS 2	C	3 (?)	SOL	ac	Álvarez-Lao and García, 2012
96	Cueto de la Mina	Asturias	MIS 2	C	3 (?)	SOL	ac	Domingo et al., 2005; Álvarez-Lao and García, 2012
97	EDAR Culebro	Madrid	MIS 5	OA	2	MP	spp	Panera et al., 2017; Yravedra et al., 2014
98	Casa Eulogio	Madrid	LP	OA	2 (?)	MP		Álvarez-Lao and García, 2012; Panera et al., 2014
99	Arriaga	Madrid	LP	OA	2 (?)	MP		Álvarez-Lao and García, 2012; Rubio-Jara et al., 2016
100	Algar de João Ramos	Leiria	MIS 2	C	1			Antunes and Cardoso, 1992

Table 6.4: Iberian sites with *Mammuthus primigenius* specimens and references. The location of the sites (numbers) in the Iberian Peninsula can be seen in Figure 6.1. For the abbrevations see Table 6.1.

an anthropogenic primary access, and they reserve the role of secondary consumers for hyenas. This site is a good example for illustrating the difficulties of interpreting this type of assemblages.

A similar degree of competition between hominins and carnivores was proposed for the Barranc de la Boella site (Tarragona; Pineda et al., 2014). This site is magnetostratigraphically dated to post-Jaramillo/pre-Brunhes, and it is known for containing one of the oldest Acheulean records in western Europe (Vallverdú et al., 2014). As in the case of Orce, Barranc de la Boella is also located in a fluvio-lacustrine setting, in which several faunal and lithic remains have been recovered.

Figure 6.2: View of the Fuente Nueva-3 site (Orce) (photo courtesy of Bienvenido Martínez-Navarro, IPHES).

Mammoths (*Mammuthus meridionalis*) are also common, along with ungulates, such as horses, different species of deer, hippo, rhinos and wild boar. Several taphonomic processes, such as trampling, seem to have significantly affected the preservation of bone surfaces and the original position of the remains (Pineda et al., 2015). A possible contact between humans and mammoths from two ambiguous cutmarked ribs was suggested by Mosquera et al. (2015). In any case, the site offers an important potential to find clues to bring light to this issue in the near future.

6.4 MIDDLE AND LATE PLEISTOCENE

As previously mentioned, Torralba and Ambrona are probably the most well-known sites with elephants associated to artifacts in the Iberian Peninsula. Both sites were discovered at the end of the 19th century and quickly attracted the attention of many researchers (Fig. 6.3A, B). During the second half of the 20th century, the sites acquired great scientific recognition due to the work carried out by an international team (e.g., Howell et al., 1963). Torralba and Ambrona are two Acheulean open-air sites located very close to each other, which are related to the palaeolakes located at the bottom of a karstic plain (polje). Although, originally, both sites were considered contemporaneous, current data show significant chronological differences. Ambrona has been dated by electron spin resonance (ESR) to MIS 11–9 (Falguères et al., 2006), whereas Torralba, dated by optically stimulated luminescence (OSL), seems to be much younger (~MIS 7; Santonja et al., 2014a).

At Torralba, elephants classified as *Palaeoloxodon antiquus* are the most represented large mammal, together with horses. Aurochs, rhinos, hippos and different deer species compose the spectrum of large herbivores. The site also contains charcoal fragments that were initially interpreted as the product of some type of anthropogenic activity; perhaps torches or burned vegetation used to lead the animals to traps located near the lakes. Therefore, the assemblages were long considered as kill sites of elephants, where hominins used large cutting tools to process the carcasses and elaborated pointed tools with their tusks (e.g., Freeman, 1978; Howell and Freeman, 1983). This idea was refuted with

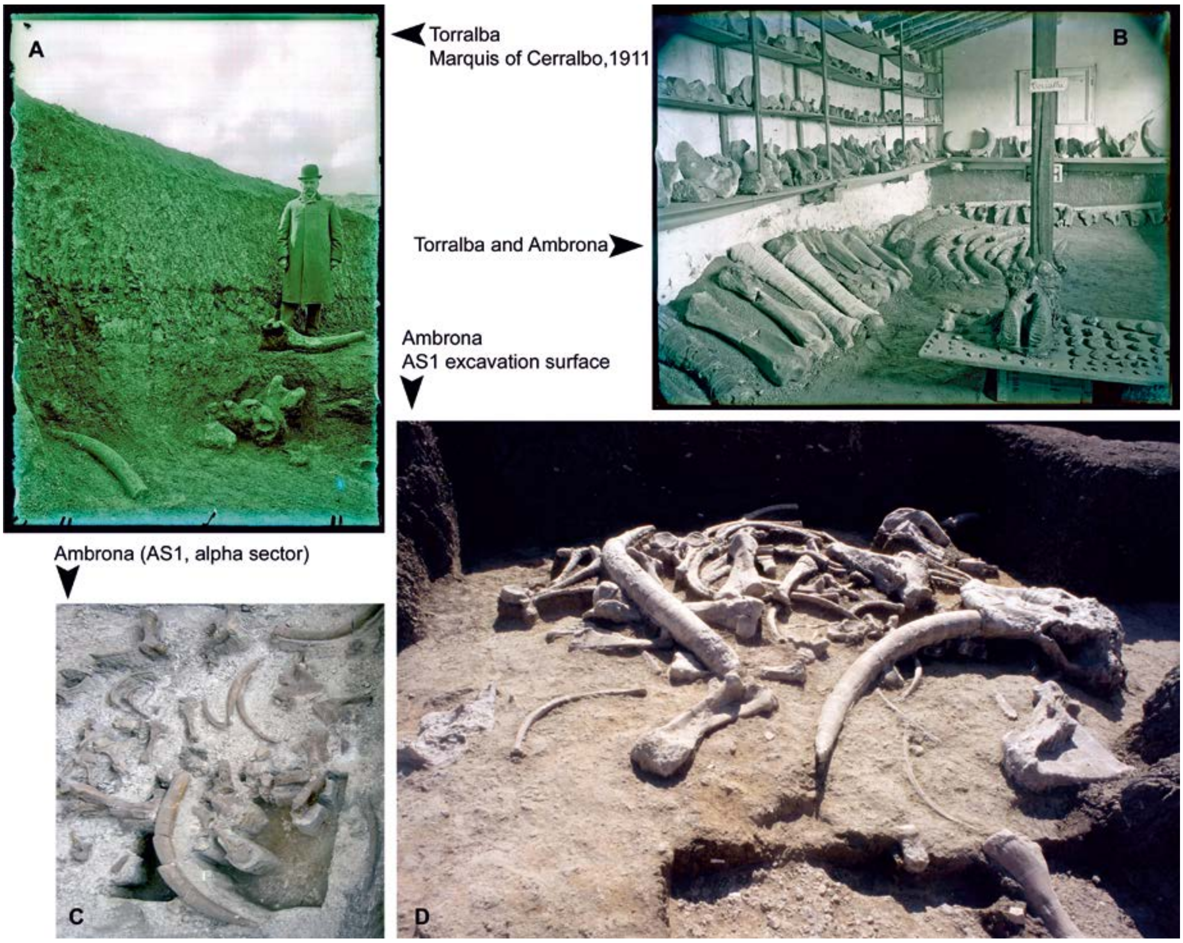

Figure 6.3: **A**, discovery of the first elephant remains in Torralba with the Marquis of Cerralbo during the 1911 fieldworks (photo courtesy of J. Cabré Aguiló); **B**, elephant specimens and lithic tools from Torralba and Ambrona; note the quality and quantity of the archaeo-palaeontological material (photo courtesy of J. Cabré Aguiló); **C**, *Palaeoloxodon antiquus* partial skeleton from Ambrona (AS1, alpha sector) (photo courtesy of M. Santonja); **D**, detail of the Ambrona AS1 excavation surface currently exhibited at the Museum *in situ* of Ambrona (photo courtesy of J. Panera).

taphonomic data collected by Shipman and Rose (1983), and different alternative interpretations were proposed since then. Villa (1990) examined the materials that came from more recent field seasons, reaching conclusions similar to Shipman and Rose (1983). Nevertheless, the poor preservation of most bone cortical surfaces, together with a possible disturbed sedimentary context, led her to question possible interactions between hominins and these animals. In any case, Villa's (1990) study concludes that, based on the taphonomic evidence, Torralba can no longer be considered a kill site of elephants.

Broadly speaking, Ambrona showed similar characteristics (Fig. 6.3C, D). The dominant fluvio-lacustrine environment in the assemblages seems to have affected part of the materials, which can be observed especially on the lithics (Santonja et al., 2014a). Anthropogenic damage on bones, mainly cut marks, demonstrates the association between lithics and faunal remains (Villa et al., 2005). However, the evidence of human activities is limited and not strong enough to support the idea of a persistent human population in the region during this period. Even so, the authors suggest that there were recurring visits of human groups to the region for thousands of years, probably attracted by the herds of herbivores that regularly visited the lakes. One of the most significant assemblages found at this site comes from the

Figure 6.4: *Palaeoloxodon antiquus* from the Orcasitas site (photo courtesy of Museum of the Origins - San Isidro).

lower stratigraphic member (AS3) in which the partial skeleton of a male elephant was recovered with several lithic artifacts and isolated remains of two other individuals. According to Santonja et al. (2014a), the sedimentary context corresponded to the mud deposited by low-energy water flows on a shallow pond. Taphonomic analyses showed slight dislocation of the materials, probably because the assemblage remained unburied for a time and was exposed to different processes, such as trampling. This phenomenon could explain the disarticulation, displacement and overlapping of several bones. Although trampling striations are common on bones composing the assemblage, several elephant surfaces show cut marks: a maxilla, an ulna and three fragments of femur (Villa et al., 2005). Besides, two limb bone shafts show diagnostic elements of intentional breakage to obtain marrow. The AS3 evidence is not an isolated case; cut marks on elephant bones were also recognized on some bones from the immediately upper stratigraphic member (AS4), suggesting more regular elephant carcass processing at the site. The elephant event from the AS3 met spatial characteristics similar to those observed at Fuente Nueva-3, with lithics around a partial carcass. The differences lie in the technology used for the elaboration of the artifacts (Oldowan vs. Acheulean) and the presence or absence of anthropogenic bone damage, which seems to be related to bone surface preservation.

Proboscidean specimens were common in the south of the Iberian sub-plateau during the second half of the Middle Pleistocene and the beginning of the Upper Pleistocene (until MIS 4). Several fluvio-lacustrine localities of this geographic area contain assemblages composed of elephant bones

Figure 6.5: *Palaeoloxodon antiquus* partial skeleton from Áridos 2 (photo courtesy of M. Santonja).

(showing different preservation degrees), mainly *Palaeoloxodon antiquus* and lithic artifacts related to the Acheulean and post-Acheulean technologies. Some of these sites are located in the Jarama and Manzanares valleys (Madrid), such as San Isidro, Orcasitas, Arenero de Rojas, PRERESA, Transfesa, Valdocarros and Arriaga IIa, or those located in the Tajo Valley, such as Pinedo (Toledo; Santonja et al., 2014b; Yravedra et al., 2012, 2014) (Fig. 6.4). Unfortunately, most of them correspond to old discoveries, and the existing data do not allow for making accurate assessments. In spite of this, some collections have been recently revisited, and interesting taphonomic data have been reported. One of the most significant sites in this area is Áridos in the south of Madrid, which presents two different and practically contemporaneous locations (Áridos 1 and Áridos 2) dated by amino acid racemization (AAR) and ESR in the MIS 11 (Yravedra et al., 2010). Both assemblages correspond to flood-plains where a partial carcass of *Palaeoloxodon antiquus* was found. In the case of Áridos 1, the specimen is a female with several preserved bones scattered around a surface of 50 m2. The assemblage also contains more than 300 lithic Acheulean artifacts, among which flakes, handaxes and percussors stand out. In general, no remarkable differences with previous bone assemblages can be reported. Nevertheless, it is worth mentioning that several lithics were refitted, showing intense knapping activities linked to the configuration and reshaping of large cutting tools at the site. The connections drawn by these refits seem to place the elephant at the center of the anthropogenic actions, suggesting an association between the human groups and the carcass (Santonja et al., 2014b). Although no cut marks on bones were observed, the assemblage was interpreted as a single event of human processing of an elephant in a non-competitive context (Villa, 1990). A similar accumulation is documented at Áridos 2 (~150 m away), although higher hyena activity stands out as a difference (Santonja et al., 2014b; Villa, 1990) (Fig. 6.5). At this site, the elephant specimen was an old male that preserved an articulated part of the rib cage, and the right scapula and humerus. A fragment of the skull was also recovered. Unfortunately, the site was partially destroyed before the discovery, and this situation prevents an adequate assessment of the anatomical profile. The lithics were classified as Acheulean, and their quantity is higher than 30. A re-examination of the assemblage indicated the presence of cut marks clustered on several groups: two on the ventral side of one rib, and three on different points of the scapula (Yravedra et al., 2010). Carnivore damage was also detected in the form of tooth marks and furrowing at the distal end of the humerus. According to Yravedra et al. (2010), the presence of cut marks related to viscera removal could suggest primary and immediate access by the human groups to the carcass, followed by secondary access by the hyenas.

At the eastern border of the Plateau, the Cuesta de la Bajada site (Teruel) represents a different case. This site is located in a terrace of the Alfambra River dated to MIS 9–8 by OSL and ESR (Santonja and Pérez-González, 2014). Several assemblages were discovered at Cuesta de la Bajada and interpreted as the result of hunting activities by the human groups of the region (Domínguez-Rodrigo et al., 2015). The main prey were horses and red deer, although other ungulates were also recovered, such as aurochs, rhinos, wild goats and chamois. The lithics were configured from local raw materials, and the reduction sequences seem to have been completed on the site. The presence of Quina, discoid and Levallois, as well as side-scrapers and denticulates, place this technology in the early Middle Palaeolithic. The presence of elephants was detected through isolated bones, which allowed identifying at least two individuals: one at CB2 and another at CB3. The individual from CB2 is represented by an isolated phalanx, while the individual from CB3 presents one mandible, three long bones, one carpal, one phalanx and two unidentified fragments. The main difference regarding previous cases is the context in which these specimens were recovered. At Cuesta de la Bajada, the elephants appear mixed with other ungulates that exhibit anthropogenic damage as a reflection of intense human activities there. The assemblage seems to have been formed by the anthropogenic transport of ungulate portions from nearby areas. Nevertheless, the elephant bones do not bear clear human modifications beyond notches on two mid-shafts of ambiguous (human or carnivore) origin. Even so, the high anthropogenic component of the assemblage is clear and could suggest an association between ungulates and human activities.

In the south, the fluvio-lacustrine site of La Solana del Zamborino (Granada) contains three stratigraphic units with isolated remains of elephants in addition to lithic tools and remains of many other ungulates, including horses, red deer, fallow deer, roe deer, aurochs and hippos. These elephants have been classified as *Mammuthus trogontherii* in the upper stratigraphic unit and *Palaeoloxodon antiquus* in the lower two (Botella et al., 1975; Ros-Montoya, 2010). Recent magnetostratigraphic studies suggest a chronology of 480–300 ka (Álvarez-Posada et al., 2017), which is consistent with a late Acheulean and an early post-Acheulean assemblage in western Europe. The site was initially interpreted as a kill site, similar to the first considerations made about Torralba. However, the lack of anthropogenic marks on the elephant remains make it difficult to establish a clear relationship between these animals and the human groups.

The most recent case corresponds to the fluvial location of PRERESA (Madrid), dated to MIS 5 by OSL (Santonja et al., 2014b). The macromammal record is composed of different ungulate taxa, among which horses, aurochs, red deer, fallow deer and roe deer predominate. Carnivores are also present, mainly wolves, foxes, lynx and badgers, although their incidence is very scarce (Yravedra et al., 2012). Lithic artifacts are composed mainly of flakes made on flint and, to a lesser extent, quartz. The reduction sequences are short but complete. The most significant characteristic of PRERESA is the presence of the partial carcasses of an aurochs and an elephant (Elephantidae indet.) scattered on a surface of more than 100 m2. The elephant is represented by 82 bones (cranial, axial and limb bones), suggesting that the whole carcass was probably originally at the site. According to Yravedra et al. (2012), this animal was intensively processed by human groups. Several bones show cut marks (n = 6) and evidence of bone breakage, mainly percussion notches, flakes and percussion marks (n = 7). This case can be considered the first

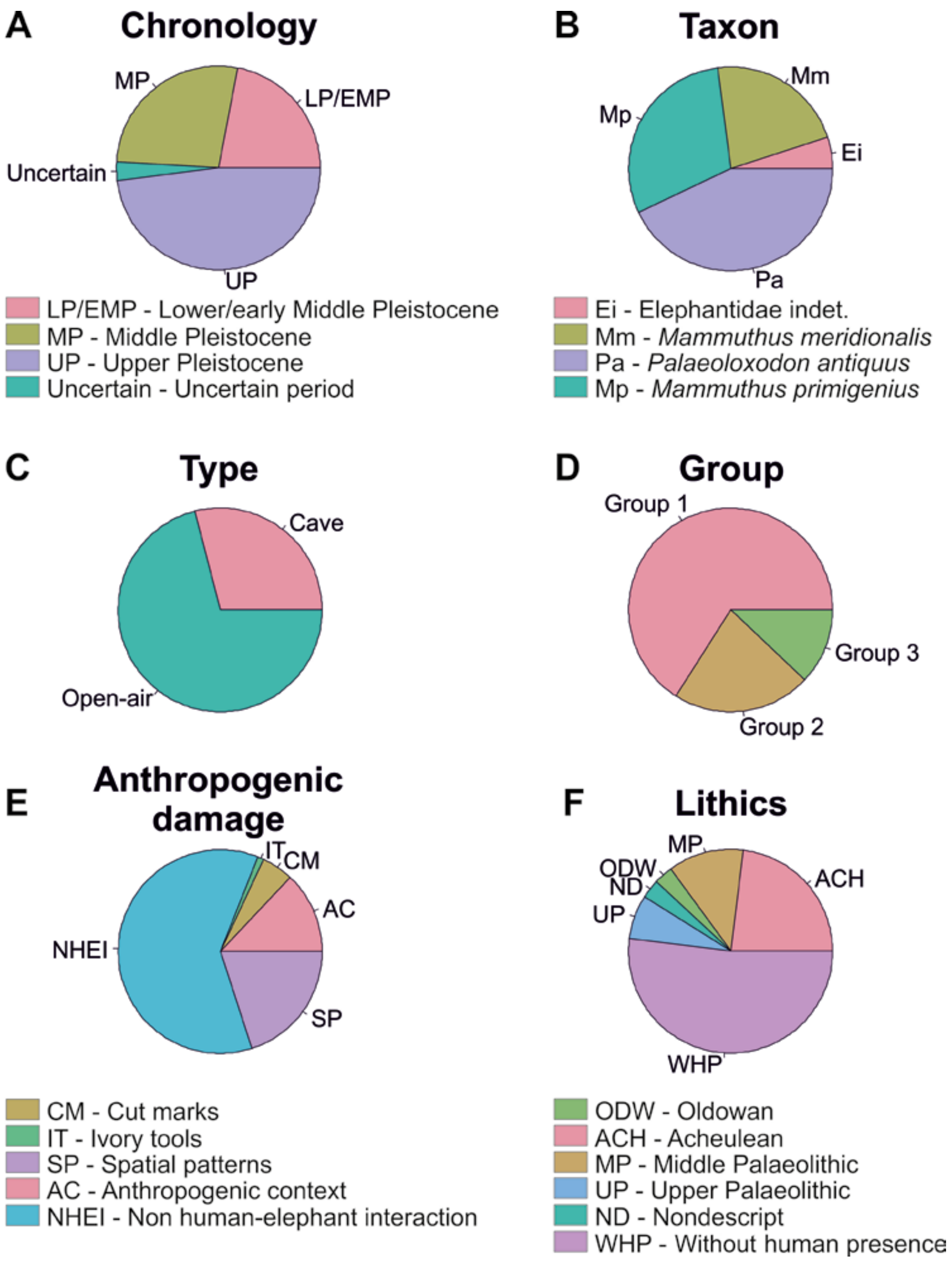

Figure 6.6: Pie charts showing some of the main characteristics of Iberian sites with proboscidean specimens.

example of marrow removal in elephants from the Iberian Peninsula.

On the Mediterranean coast, Bolomor Cave (Valencia) provides a different case for the subject discussed here. This site is a rock shelter located in the mountainous foothills closest to the sea (Blasco et al., 2013; Blasco and Fernández Peris, this volume). The stratigraphic sequence is formed by 17 levels dated between the MIS 9 and 5. Recurrent anthropogenic occupations are documented along this sequence with a high diversity of prey and a very rare presence of carnivores. Human occupations are characterized by post-Acheulean technology and by the regular use of fire, especially from unit XIII onwards. Elephants are present in several stratigraphic levels, specifically at Ia, IV, V, XII, XIII and XVII. All of them are represented by isolated remains (teeth, cranial, limb bones, acropodials and basipodials) of mainly immature individuals. No axial bones (vertebrae or ribs) were recovered. Cut marks were identified on a mandible (level XII), as well as fresh bone breakage and burning damage (levels I, IV). The main characteristics of the remains, together with the rest of the faunal assemblage, suggest anthropogenic transport of selected anatomical portions to the site (Blasco et al., 2013; Blasco and Fernández Peris, this volume).

The MIS 4 represents a turning point for the Iberian elephants, as their presence decreases significantly in the taxonomic lists from archaeological sites. This phenomenon could be caused by the low number of open-air fluvio-lacustrine locations with well-preserved faunal specimens and the cold climatic conditions during the MIS 4 and the subsequent MIS 3. However, this seems to be inconsistent with the last occurrence of *Palaeoloxodon antiquus* in Iberia, which was dated to ~33 ka BP at Foz do Enxarrique (Castelo Branco; Aguirre, 1968, 1969a, b; Antunes and Cardoso, 1992). Besides, the coldest pulsations could have represented several entries of woolly mammoths (*Mammuthus primigenius*) to the Peninsula from the Pyrenees and the Cantabrian Mountains, establishing occasional relict populations that could last over time (Álvarez-Lao and García, 2012). The last occurrence for this taxon in Iberia is dated to 14 ka BP at Algar de João Ramos (Leiria; Antunes and Cardoso, 1992). Even so, the presence of proboscidean specimens in anthropogenic contexts is not common during the Iberian Late Pleistocene, and most of the cases correspond to isolated bones that make it difficult to establish an association with human groups. Reports about these megaherbivores are most common in the north of the Iberian Peninsula, mainly along the Cantabrian coast at archaeological sites such as Labeko Koba (Basc Country), Minas de Heras, Pámanes, Cueva Morín, Udías, Mina Ángel, El Cierro, La Lloseta and La Güelga in Cantabria; Las Caldas in Asturias; or Bujan in Galicia (Álvarez-Lao and García, 2012). Along the Mediterranean coast, the presence of these animals has been identified at sites framed within the end of the MIS 3, such as Arbreda, Cau de les Goges, Teixoneres Cave and Abric Romaní in Catalonia (Arribas, 2004; Rosell et al., 2012, Álvarez-Lao et al., 2017; Rufi et al., 2018). The Central Plateau contains remains of this taxon at sites such as Casa Eulogio, Arriaga and Butarke in Madrid (Arribas, 2004). Mammoths also arrived at the Atlantic coast from Portugal, specifically at the Extremadura sites, such as Figueira Brava and the aforementioned Algar de João Ramos (Antunes and Cardoso, 1992). The southernmost case corresponds to the Baetic Mountain Range, specifically at Padul (Granada). However, none of these sites offers enough guarantees to infer direct (and regular) contact between elephants and humans during the Upper Pleistocene in Iberia.

DISCUSSION AND CONCLUSIONS

The regular exploitation of proboscideans in Europe during the Palaeolithic has been a long-debated topic, especially for the implications it has for establishing the evolution of the subsistence behavior of human communities (e.g., Frison, 1978; Frison and Todd, 1986; Gaudzinski et al., 2005; Surovell et al., 2005; Surovell and Waguespack, 2008; Konidaris and Tourloukis, this volume). With few exceptions, as in the case of La Cotte de St Brelade (UK; Smith, 2015) or Lehringen (Germany; Thieme and Veil, 1985), well-documented reports of elephant-human interactions during the Lower and Middle Palaeolithic on the continent are scarce and often difficult to interpret, which can lead to some confusion (Haynes, 2005; Giusti, this volume). The data previously exposed show how some archaeological sites of the Iberian Peninsula have contributed to the debate since its beginning, such as Torralba, which was long considered a kill site. This geographical area had, in the past, a continuous presence of different proboscidean species that were distributed in different climatic domains during all the Pleistocene periods (Fig. 6.6A). Even during the colder pulsations of the Upper Pleistocene, when the northern mountain ranges functioned as a biogeographic barrier for many mammals (e.g., reports on reindeer at the south of the Pyrenees and the Cantabrian Mountains is very rare), woolly mammoths expanded throughout the territory, reaching the south, as is the case of Padul in Granada (Fig. 6.6B). This phenomenon can only be understood by the versatility and high adaptability of this taxonomic group.

From a zooarchaeological perspective, the Iberian Peninsula could be a good setting to understand the evolution of the relationships between humans and proboscideans throughout Prehistory. However, the evidence recovered so far is limited and does not allow for inferring basic aspects, such as the procurement methods, frequency of exploitation, or carcass processing techniques. This shortage of evidence could be due to several factors that are not mutually exclusive. First, a large part of the localities are open-air sites in fluvial-lacustrine environments and yield the typical bone modifications from these types of context, including those generated by exposure to weather and water runoff, which are among the most common (Fig. 6.6C). These conditions usually mask possible previous evidence left by both humans and carnivores, making interpretations difficult. This case has been well studied in the Barranc de la Boella at the experimental level, where the authors have determined that the site formation processes, which include leaching and rolling due to water runoff, generate similar morphologies between possible cut marks and marks generated by the friction of sediment particles on the bone surface (Pineda et al., 2014). Second, it should be remembered that many sites were excavated during the early years of exploration, without an adequate archaeological methodology, and at a time of development of the discipline in which the chronocultural classification of sites was prevalent. This caused some cases of overinterpretation, as in Torralba (Villa, 1990), but it is also possible that some assemblages went unnoticed due to the impossibility of recognizing signs of human presence beyond lithic industry. Third, it is worth remembering the low frequency of cut marks on megaherbivore bones, as experimentally and ethnographically detected by several researchers (e.g., Frison and Todd, 1986; Frison, 1989; Haynes, 1991, 2005). According to these studies, the thickness of the muscle masses and periosteum of these animals usually prevents stone tools from contacting the bone surface during the defleshing process with the same frequency that occurs in other smaller size animals. Thus, although the reports of proboscidean use as food are scarce and sometimes dubious, there may be unknown cases that should be reviewed in the future. Finally, it is also important to highlight that the use of the elephant bones as raw material for the configuration of tools has not been identified in the Iberian Peninsula, at least not as it has been registered in many other places in the Old World (e.g., Anzidei, 2001; Gaudzinski et al., 2005; Rabinovich et al., 2012; Boschian and Saccà, 2015). Tools made with ivory were initially described at Torralba (Howell, 1966; Howell and Freeman, 1983), although they were soon discussed and refuted by other researchers (e.g., Binford, 1987; Haynes, 1991; Villa and d'Errico, 2001). To date, this type of tools in Iberia is only recognizable in the Upper Palaeolithic, as is the case of a punch made on a fragment of mammoth ivory from Cau de les Goges (Girona) (Pallarès and Wernert, 1915–20).

With all this in mind, the oldest so far evidence of elephant exploitation in the Iberian Peninsula (as well as in Europe) is possibly recorded in the Lower Pleistocene site of Fuente Nueva-3, in Orce. According to Espigares et al. (2013, 2019, this volume), humans and hyenas would have competed for access to an elephant carcass. However, the poor preservation of bone surfaces makes the identification of cut and carnivore tooth marks difficult, as well as establishing the action sequence. The same occurs in the Barranc de la Boella, as previously discussed. In this latter case, the elephant remains appear widely dispersed, and causal association with the lithic industry is difficult to establish. Both archaeological sites can be considered examples of the interpretative difficulties in the open-air assemblages, as many questions remain open.

The localities we register here allow us to establish three main groups (Fig. 6.6D). The first group (group 1) includes sites without human activity or those where the indications observed so far are insufficient to relate human activities to the proboscidean carcasses. This would be the case of Torralba, where human action seems to be mainly focused on other ungulates. The second group (group 2) corresponds to those sites with whole or partial elephant carcasses, with a high degree of articulated or semi-articulated bones, and with clear contact evidence between lithic artifacts and elephant bones. This would be the case of Ambrona, Áridos 2 and PRERESA, where cut marks and intentional bone breakage have been identified. Áridos 1 and the Solana del Zamborino could also be included within this category because clear knapping and shaping activities of lithic artifacts (and traces) were identified around the elephant carcass. The third group (group 3) would correspond to those sites with predominantly anthropogenic contexts, where elephants are represented by isolated remains along with other dominant taxa (in most cases horses and deer) and interpreted as the product of anthropogenic accumulation. This group would include the Cuesta de la Bajada and Bolomor Cave.

Based on this, the two groups with human signatures (groups 2 and 3) are used here to analyze the main objective of this work (Fig. 6.6E, F). The main differences between them are the taxonomic diversity observed in the faunal assemblages, the minimum number of individuals (MNI), the integrity of the carcasses and the duration of the events. The group 2 sites are usually characterized by one elephant individual, with high integrity of its skeleton (sometimes with high proportion of articulated bones) and by being interpreted as very short-term events. From an ethnoarchaeological point of view, there are interesting parallels that can be used to include them within the category of kill or butchering sites, and which show that the processing patterns of megaherbivores (>1000 kg) have undergone few variations since ancient times (Crader, 1983; Bunn et al., 1988; O'Connell et al., 1988a, b; Bartram, 1993). According to these observations, the presence of a very large carcass usually motivated the mobilization of all or a large part of the group members to the place where it was obtained in order to process the animal and consume it entirely. This situation occurred regardless of the procurement method (hunting or scavenging, including intermediate phases) and did not usually require the use of complex technologies beyond the lithic tools used by butchers. In some specific cases, the transport of selected anatomical portions occurred and may have included large packages of meat and fat and isolated bones, such as phalanges, metapodials and some long bones. The most common result was the abandonment of articulated carcasses that were subject to the ravaging and atmospheric agents. Thus, the sites belonging to group 2 in the peninsular archaeological record could be registering similar processes, in which the only observed variation is the lithic technology used and the development of more or fewer knapping activities at the site. The absence of appendicular elements at some sites could be related both to anthropogenic transport towards the habitat place and the subsequent carnivore action or natural agents. Among all the Iberian localities, only Áridos 2 allows for inferring some activity beyond the defleshing and bone breakage to obtain marrow. In this case, the cut marks observed on the ventral surface of ribs could suggest viscera removal and, therefore, early human access to the carcass. On the contrary, group 3 (i.e., those sites with isolated elephant bones accumulated together with other ungulates) seems to complement the ethnoarchaeological parameters previously described. The best representatives of this group, Cuesta de la Bajada and Bolomor Cave, have been interpreted as places where human groups accumulated the remains of their prey. The different assemblages were formed by a succession of events of a relatively long duration, where domestic activities linked to butchery and consumption of prey were developed. The retrieved specimens correspond to autopodial bones, some long bones and mandibles. With the exception of mandibles, the rest are those that, according to ethnoarchaeological observations, are liable to be moved. From this point of view, the importance of elephants in these sites could be underrepresented because human transport decisions could include only meat and fat and exclude most or all of the bones. This could significantly alter the zooarchaeological perception of the assemblages (Ben-Dor and Barkai, this volume).

At this point, it is worth highlighting the case of Bolomor Cave. This site yields several isolated elephant bones in some archaeological levels and is the only one located in a karstic context. Another peculiarity of this locality is the presence of hearths in several archaeological levels, which point to the use of fire as a possible central point in domestic activities (Fernández Peris et al., 2012). The taxonomic diversity in the main faunal assemblages (e.g., I, IV, XI, XII, XVII) is high and has been interpreted as the product of the territorial stability of human groups in a rich environmental context (Blasco et al., 2013). The proboscidean remains, although not very abundant, correspond mainly to immature individuals and can be clearly associated with human activities due to the presence of cut marks and/or burning damage (Blasco and Fernández Peris, this volume). In this case, perhaps, the lower weight of immature individuals could have facilitated a higher rate of transport of selected parts, which would be significantly reduced with adult individuals.

Another important aspect to highlight in the Iberian Peninsula is the absence of clear human–elephant relationships from the MIS 4. During this period, coexistence with woolly mammoths seem to have been frequent in much of Europe during the late Middle Palaeolithic (e.g., La Cotte de St Brelade), and these are multiplied significantly from the Upper Palaeolithic onwards. However, the shortage of remains of this species in the southern Pyrenees and the Cantabrian Mountains has always been explained by the southern climatic characteristics of this geographical area, which would have represented a refuge for temperate-adapted species and a barrier for cold-adapted ones. Thus, sites whose faunal lists indicated the presence of this species were used to contain isolated bones that did not represent the focus of the studies. Their presence in these sites, together with some graphic representations of mammoths during the MIS 2 (e.g., the Casares site, Guadalajara, Spain; Arribas, 2004), were explained as sporadic entries during the colder pulsations. Nevertheless, the geographical and temporal distribution of the sites with mammoth remains suggests a more continuous presence of this taxon in the Iberian landscape throughout the Upper Pleistocene. The absence of contact evidence with human groups could be explained by other phenomena, such as the low presence of open-air sites with preserved fauna.

In summary, there are many limiting factors that make it difficult to assess human–elephant relationships during the Palaeolithic in Iberia. Besides the poor preservation of bone cortical surfaces due to taphonomic causes, it is necessary to add the time of formation of the assemblages, which frequently prevents establishing secure associations. This occurs, for example, in Torralba, where the presence of several elephants concentrated in the same area could be the result of a significant diachrony. In this line, Haynes (2005) indicates the difficulty of explaining synchronic accumulations of several individuals in the same place due to natural causes. Anthropogenic phenomena that could produce accumulations of this type, such as episodes of communal hunting or mass predation, are rare in contexts prior to the late Upper Palaeolithic and, therefore, are difficult to justify in the Middle Pleistocene without a battery of clear evidence.

The evidence from Iberia shows that elephants were included in the human diet since the Early Pleistocene. Nevertheless, the available evidence does not guarantee regularity in the exploitation of these animals. Most of the sites do not seem to correspond to hunting activities, at least as had been initially suggested in some localities from group 2, with the use, for example, of mud traps (see the first interpretations for Torralba, Ambrona or Solana del Zamborino). From a zooarchaeological point of view, it is most prudent to think in terms of: 1) fortuitous encounters based on a low rate of dead carcasses, 2) the complete (or practically complete) carcass processing at the procurement place, and 3) the occasional transport of selected anatomical portions due to different reasons, such as animal body weight and distance to the habitat location (in the case of group 3).

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7. UPPER PLEISTOCENE HOMININS AND WOOLY MAMMOTHS IN THE EAST EUROPEAN PLAIN

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ABSTRACT

In Europe, the Last Glacial period was mostly characterized by a dry and cold steppe environment that supported well-adapted animal taxa, notably woolly mammoth, which coexisted with Neanderthals and anatomically modern humans. This paper provides a synthesis of mammoth and human interactions in Eastern Europe, using the results of zooarcheological analyses of faunal assemblages from the valleys of the Dnieper and Dniester Rivers in Ukraine, Republic of Moldova and Russia. We identify the burial conditions of the skeletal remains, and the human strategies of resource acquisition and utilization. We highlight the different ways mammoth resources were acquired, either by hunting or dry bone gathering, and the different uses of soft and hard materials: food, fuel, wedging and building material, and raw material for tools and mobiliary art. The mammoth was an important influence in territorial human settlements and probably had major status among the dominant species in the assemblages, which included also reindeer, horse, canids, lagomorphs, rodents and bison. The trio reindeer-horse-mammoth was important for human groups in each techno-cultural complex of the East European Plain.

7.1 INTRODUCTION

Human socio-ecological systems within particular environments are defined by technology, subsistence, symbolic practices and social partners, which may include human and non-human ani-

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mals. During the Palaeolithic human groups interacted closely with many other animal species which played significant roles in culture, as evidenced in particular by archaeological assemblages containing animal remains linked to subsistence practices and symbolic animal representations. In this chapter, we present a synthesis about mammoths in Upper Pleistocene archaeological sites of Eastern Europe, with emphasis on the distinctiveness of mammoth remains in archaeological sites and interpretive results obtained from recent studies of mammoth assemblages.

7.2 CONTEXT

7.2.1. CHRONO-CLIMATIC CONTEXT, GEOGRAPHIC FRAMEWORK, AND PALAEOENVIRONMENT

CHRONO-CLIMATIC CONTEXT | The Upper Pleistocene began ~126,000 years ago and lasted until ~11,700 years ago. Most of the Upper Pleistocene (Marine Isotope Stages or MIS 2, 3, 4 and 5a–d) was marked by the last ice age. This cooling period resulted in a marine regression (a general drop in sea level) of ~120 meters and the establishment of a periglacial climate in Europe, leading to profound changes in fauna and flora (Velichko and Zelikson, 2005; Velichko et al., 2011). This ice cycle has been subdivided in different ways:

- a unique glaciation, Valdai (also known as Weichselian), with Briansk interstadial;
- two distinct glaciations, the first and older one known as Kalinin, followed by the Mologo-Cheksna intermediate period, and the second and younger one known as Ostashkovo (Ivanova, 1969).

Although opinions differ on these episodes, they are unanimously recognized as three isotope stages: the Lower Pleniglacial (70,000–60,000 BP, MIS 4), the Middle Pleniglacial or Interpleniglacial (50,000–26,000 BP, MIS 3) and the Upper Pleniglacial (26,000–10,000 BP, MIS 2). However, there is some disagreement about the beginning and ending dates for these periods. For example, Clark et al. (2009) dated the end of the Upper Pleniglacial at ~13,500 yrs BP, at the Bölling oscillation, followed by the Tardiglacial period. Velichko and Kurenkova (1990) dated the end of the Ostashkovo glaciation, including the maximum extension of the ice sheet between 20,000 and 18,000 BP, to 16 000 BP, followed immediately by the Tardiglacial. In Haesaerts et al. (2003), the Pleniglacial is a single set of phases divided into three parts:

- the first part of the Upper Pleniglacial (26,000–20,000 BP) (Last Glacial Maximum-LGM: 23,000–20,000 BP);
- the second part of the Upper Pleniglacial (20,000–14,000 BP); and
- the final part of the Upper Pleniglacial, transition to the Holocene (14,000–10,000 BP).

According to simulations of the Last Glacial Maximum (Banks et al., 2008), the mean temperatures in Eastern Europe ranged from 0 to 6°C. The warm periods were characterized by mean temperatures between 16° and 20°C, and the coldest periods by mean temperatures between -13° and -4°C. Annual precipitation ranged from 80 to 150 mm.

GEOGRAPHIC FRAMEWORK | The East European Plain is the largest area of the European continent, near the boundary of Europe and Asia. It is delimited by the Carpathian, Ural and Caucasus mountain ranges. Several major rivers and their tributaries drain this territory: Vistula, Neman, Dnieper, Volga, Don, Southern Bug, Danube and its tributaries Siret and Prut, and Dniester. This area is divided into four main regions: the extracarpathic area, the plain, the pontic steppe and the Crimean Mountains (Fig. 7.1).

PALAEOENVIRONMENT | During the Pleniglacial, continental ice sheet and expanded mountain gla-

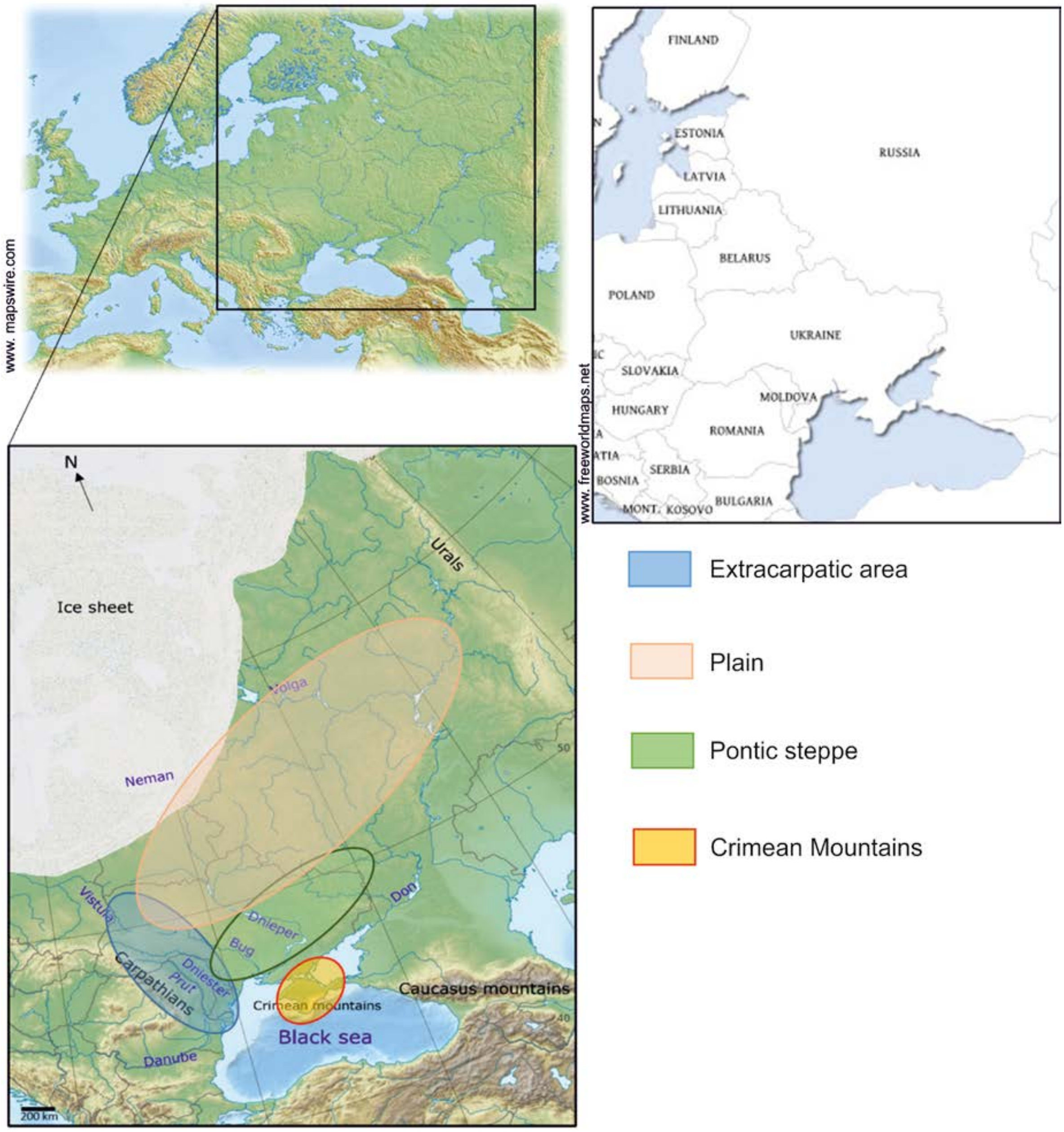


Figure 7.1: The East European Plain in Europe, with the actual countries and the geographical configuration during the Last Glacial stage, including main rivers, mountains and geographic regions. Maps were taken from the freely available websites www.mapswire.com, www.freeworldmaps.net and made by Alexrk2 with the free to share license Creative Commons Attribution-ShareAlike 3.0 Unported License (https://upload.wikimedia.org/wikipedia/commons/7/79/Europe_relief_laea_location_map.jpg).

ciers covered much of the Northern hemisphere. Continuous permafrost and active permafrost soil (mollisol) were present in a large part of Europe. The extent of frozen ground varied according to seasonal and longer climatic variations. As today, mollisols then would have thawed in summer by supplying and conducing heat from the surface. Plants and small organisms (micromammals, molluscs, insects) could thus have survived in permafrost regions. An active zone of seasonally discontinuous frozen ground existed in the northern part of the East European Plain.

The ice sheet modified the circulation of the winds, allowing plants adapted to the cold climate to expand considerably (Novenko, 2006). Europea at that time was characterized by a tripartition of plant communities: a periglacial tundra and steppe in active permafrost environments and boreal forests in some places (Klein, 1973; Velichko, 1981; Grichuk, 1982). There were also smaller local environments, such as mountains with steep cliffs with different biota. Generally, the periglacial steppe dominated with halophytic plants. This type of shrubby steppe, composed of herbaceous plants and scattered clumps of trees (pines, birches, junipers), is characteristic of a cold and dry climate with strong sunshine, and favored the existence of large herds of herbivores (Guthrie, 1982).

The Dnieper and Dniester river valleys in the Pleniglacial were characterized by sparse wooded areas along the rivers, of forest-periglacial steppe type (Łanczont and Madeyska, 2005). Forest was more extensive in the Dniester-Prut valleys.

7.2.2. PALAEONTOLOGY AND ARCHAEOLOGY

FAUNAL SPECTRUM | The mammalian fauna of the Late Pleistocene was distributed according to altitude, hydrographic network and type of vegetation. The largest species were *Mammuthus primigenius* (woolly mammoth) and *Coelodonta antiquitatis* (woolly rhinoceros). Other common large taxa were *Equus* sp. (horse), *Cervus elaphus* (red deer), *Megaloceros giganteus* (giant deer), *Alces alces* (elk), *Bison* sp. (bison), *Bos primigenius* (auroch), *Ovibos moschatus/pallantis* (muskox) and *Ursus spelaeus* (cave bear). The medium-sized mammals were *Rangifer tarandus* (reindeer), *Capreolus capreolus* (roe deer), *Saiga tatarica* (saiga antelope), *Capra ibex* (ibex), *Rupicapra rupicapra* (chamois), *Canis lupus* (wolf), *Ursus arctos* (brown bear), *Panthera leo spelaea* (cave lion), *Lynx lynx* (lynx), *Crocuta crocuta spelaea* (cave hyena) and *Sus scrofa* (wild boar). The small-sized mammals were *Vulpes vulpes* (red fox), *Vulpes lagopus* (polar fox), *Vulpes corsac* (corsac fox), *Felis sylvestris* (wild cat), *Mustela putorius* (polecat), *Mustela erminea* (stoat), *Mustela nivalis* (weasel), *Martes foina* (beech marten), *Martes* sp. (pine marten), *Meles meles* (badger), *Gulo gulo* (wolverine), *Lutra lutra* (otter), *Lepus* sp. (hare), *Ochotona pusilla* (pika), *Marmota bobac* (marmot), *Castor fiber* (beaver), *Spermophilus* sp. (souslik or ground squirrel) and *Dicrostonyx* sp./*Lagurus* sp./*Lemmus* sp. (lemming).

HOMININS AND ARCHAEOLOGY | Two hominin species were present, *Homo neanderthalensis* (Neanderthals) and *Homo sapiens* (anatomically modern humans). In Eastern Europe the last Neanderthals and the first anatomically modern humans coexisted between 36,000 and 28,000 BP in Crimea (as found at Kabazi II, Buran Kaya III and Siuren I; Demidenko et al., 1998; Chabai, 2004; Péan et al., 2013; Prat et al., 2018). Important stratigraphic sequences of Neanderthal occupations have been recorded in Ukraine (Molodova I and V, Korman IV and Dorochivtsy III), in Romania (Mitoc-Malu Galben) and Moldova (Cosăuţi) (Chernysh, 1959; Goretsky and Ivanova, 1982; Ivanova and Tzeitlin, 1987; Haesaerts et al., 2007; Koulakovska et al., 2012).

The transition between the Lower and Middle Palaeolithic stages (Acheulean and Mousterian, respectively) took place during the glacial MIS 6 (Velyky Glybochok I/IIIb). Neanderthals were present in the Dnieper and Dniester valleys, in central Ukraine, and in Crimea during the succeeding Eemian interglacial (MIS 5e). Starting with MIS 5d, leaf-shaped bifacial implements appeared, notably in Kabazi II and Zaskalnaya V in Crimea (Stepanchuk and Sapozhnikov, 2010). Thereafter the Levallois-Mousterian and the Micoquian techno-complexes were developed (Chabai, 2003). Human groups settled in all types of biotopes, generally to establish hunting camps in connection with the presence of local lithic materials. Hunting was specialized on one or two to three animal species. The main exploited taxa were horse, ibex, mammoth, reindeer, bison, saiga antelope and rhinoceros (Patou-Mathis, 1993).

Between 43,000 and 28,000 BP, various lithic industries coexisted, including Micoquian, several transitional industries (Jerzmanowicien, Bacho-Kirian, Gorodsovian, Streletskian, Sungirian, Kiik-Kobian; Cohen and Stepanchuk, 1999; Flas, 2015) and Aurignacian (Anikovich, 1992). The latter is known from a few sites in Romania, Crimea and in the Don Valley. Human groups established camps linked to the exploitation of lithic and animal resources, notably to make antler points (Noiret, 2009). The first period of the oldest phase of the Gravettian techno-complex is known in Molodova V/10-9 between 29,600 and 28,100 BP. Tools are represented notably by retouched and pointed blades, and regional particularities appeared (Otte and Kozłowski, 1982; Chernysh, 1987; Noiret, 2009).

The Epigravettian succeeded the Gravettian during the Last Glacial Maximum and lasted from 21,000 to 13,500 BP. It is mainly characterized by microlithization of tools and the use of bone needles. Several facies are distinguished in geographic regions and some sites show epiaurignacian characteristics. Many facies developed with stemmed point type during the final phase. Animal resources, notably reindeer antlers, were widely used. The subsistence base was reindeer and horse (Krotova, 1995; Kitagawa et al., 2018).

7.2.3. MAMMOTH: A KEY SPECIES

The woolly mammoth was present in the northern part of Eurasia during the Upper Pleistocene. This species began to decline in Europe from 15,000 BP along with the warming of the climate (Vereshchagin and Baryshnikov, 1984; Velichko and Zelikson, 2005). Mammoths probably were a key species in Upper Palaeolithic human life, because of the massive amounts of meat, fat, functional resources such as ivory, their long lifespans, their seasonal migrations in and out of human ranges, and their influence on landscape-shaping. Equally important, it is likely that mammoths could have been perceived as almost human-like in behavior and psychology.

MAMMOTHS CHARACTERISTICS | Because of close similarities in anatomy, size, lifespan and maturational scheduling, the biology and behavior of *Mammuthus primigenius* can be validly reconstructed based on our knowledge about the extant elephant species *Loxodonta africana* and *Elephas maximus*.

The height of adult males and females reached 2.50–3.50 meters, and body mass reached 3–4 tonnes (Larramendi, 2016). The thickness of the skin was up to 3 cm, covering a layer of fat 8 cm thick in places. Both sexes had large spiral tusks, which in older adult males could measure 2.50–3.50 m in length. The tusks are teeth mainly composed of dentin, a mineralized connective tissue with an organic matrix of collagen proteins.

Like humans, elephants pay attention to their dead to an extent unusual for ungulates. They emit different vocalizations when encountering elephant remains, especially by infrasounds, and often move the bones with feet and trunks. Sometimes they cover elephant carcasses with soil or branches (Pfeffer, 1989). Also like humans, the extant elephants are gregarious, living in family groups usually called mixed herds. The mixed herds are characterized by a highly developed sense of mutual aid. They also share resources within groups and when gathering with groups of other individuals. Both adult and juvenile individuals indulge in play. These sorts of human-like characteristics were probably also typical of mammoths.

An important characteristic of extant elephants, probably also present in mammoths, is their large-scale spatial memories over long periods of time, indicative of good cognitive mapping skills (Byrne et al., 2009). Extant elephant home ranges vary considerably from 15 to 1500 km^2, depending on the quantity and quality of food and the presence of other groups. Elephants regularly use the same paths, creating long-lasting trails connecting resource points such as feeding patches and water sources, which was undoubtedly the case for proboscideans in the Pleistocene and even deeper time (Bibi et al., 2012). These trails can be followed by humans to facilitate their movements and would have been valuable aids to navigating in unfamiliar ranges during the Pleistocene (Haynes, 2006). In dry seasons (which would have been the cold period for woolly mammoths), separate elephant herd groups and adult males often come together at water points. Elephants also frequently visit sources of mineral salts. Mammoths also would have had the same regular need for water and minerals. In some of the less productive ranges, large movements occur during migrations, as seen with some African elephant populations (Blake et al., 2003) and Asian elephant populations (Sukumar, 2003). Elephant migration distances vary considerably from one population to another: some populations are almost sedentary, whereas others are nomadic or migrate seasonally. It is relatively rare for an elephant to migrate alone. Dry or monsoon conditions that lead to shortages of resources motivate different migration distances. Migrations tend to be recurring on circular routes. Three migratory habits are recorded: movements of family groups, movements together of bond groups consisting of two to five families and movements of several mixed herds forming a single large group. Similar patterns of movement may have characterized Columbian mammoth (*Mammuthus columbi*) populations in North America (Hoppe, 2004) and likely also woolly mammoth populations.

RESOURCES FROM MAMMOTHS USED BY HUMANS | Mammoths were huge sets of resources on the hoof for Pleistocene humans, such as skins, meat, brains, viscera, fat, marrow, bones and even the dung.

Mammoth skin was thick and rigid so its uses might have been limited. Hairs could have been used to make cordage. Fat could have been used as food, for skin treatments (human skin protection, fur tanning) and to feed fires (Mulville and Outram, 2005; Costamagno and Rigaud, 2014). Meat could have been consumed, also brains and viscera. As it is very oily, brain can also be used in tanning animal hides. Cushiony pads of connective tissue, adipose, and collagen within the feet could have been eaten. The intestines, once emptied of their contents and washed and dried, could have been be twisted and made into cordage or used as containers to store bulk food. Blood could have been drunk and incorporated in the cooking.

The recovery of marrow from inside long limb bones is commonplace when humans butcher non-proboscidean carcasses, but the feasibility of accessing mammoth marrow is debatable. Proboscidean long bones do not have open medullary spaces full of edible yellow marrow, unlike most other ungulates' long bones. In proboscideans, the long bone interiors are densely packed full of hard trabecular bone with very small amounts of yellow marrow in the tiny spaces of the trabeculae. Red marrow is found mainly at the ends of the long bones where hematopoiesis takes place. Recent experiments suggest that this characteristic may vary by species, individual and type of bone (Boschian et al., 2019), but more research must be done to determine if the hard effort to extract yellow marrow would have been economically fruitful. The marrow could have been eaten raw or boiled, as it is with non-proboscidean prey animals (Binford, 1978). Fresh bones could have been used as fuel (Perlès, 1977; Théry-Parisot et al., 2005).

The use of dry bone as a combustible material is controversial. Dry bone can be used if the fire has already reached relatively high energy (Costamagno et al., 2005; Glazewski, 2006). Mammoth bones were used as combustible fuel in Krems-Wachtberg (Austria; Fladerer et al., 2014). Bones also could have been used to make cooking stock or bone broth (Saint-Germain, 1997) if impermeable vessels were available. Bones also were useful for making tools and ornaments, and as an artistic medium. The large cheek teeth could have been used as supports, such as a hypothesized seat (Goretsky and Ivanova, 1982). The enamel tooth plates could have been used to make ornaments. The bones could have functioned as material for building shelters and dwelling structures, as seen at archeological sites in Central and Eastern Europe (Pidoplichko, 1998). Ivory also could have been used as building material and was particularly preferred for tools, points and ornaments, and as an artistic medium. Ivory is a durable material that is not easily damaged or destroyed; it will not burn and is little affected by immersion in water except for slight softening of the outer (cementum) layer. It is both resistant and somewhat elastic, and can be carved and carefully shaped (Saunders, 1979; Pitulko et al., 2015).

Dry dung could have been used to start and fuel fires; dung fire smoke also would have been an effective insect repellent.

The different actions need to acquire so many useful materials from mammoths implies varying human strategies of hunting and careful management of carcasses, all taking into consideration the enormous weight of such an animal, the diverse features of morphology, the dangers encountered, and the peculiarities of each kind of material. We propose that resource-acquisition from dry found mammoth carcasses can be classified as a form of "gathering" and resource-harvesting from fresh found carcasses can be classified as "scavenging".

Apart from age, the causes of proboscidean mortality in nature are numerous. Elephantids are susceptible to accidental trauma, natural trapping, diseases and predation by social predators (lions and spotted hyenas in Africa). The most common diseases in current elephant populations are viral and bacterial infections, along with other pathologies (Fowler and Mikota, 2006). Several archaeological and palaeontological deposits have provided remains of woolly mammoths with pathologies or traumas (Leshchinskiy, 2009; Krzemińska, 2014). The extant elephants are sensitive to thermal variations and have significant water requirements, up to 150 liters per day for adults. In the event of water stress, some individuals become extremely aggressive against conspecifics, which can lead to the death of weaker individuals. Elephants also can suffer from cramps, tetany, or even heart attacks. Mammoths might have suffered similar problems, which could explain the formation of some fossil bone accumulations around water resources (springs, water holes, streams, rivers). Under conditions of severe weather or shortages of water and food, mammoths might have been able to "semi-hibernate" by depressing metabolism and reducing activity levels for extended periods of time, as seen with Yakutian horses (Guil-Guerrero et al., 2014).

In terms of mammoth hunting, human groups would have confronted an extremely strong and dangerous animal (Agam and Barkai, 2018). Mammoths' physiological characteristics were challenging to the effectiveness of prehistoric hunting weaponry. Like extant elephants, mammoths could move quickly to escape dangers such as predators, up to 40 km/h. In addition, the social solidarity of proboscideans would have been an important consideration when it came to hunting a matriarchal group of mammoths. Human hunting of mammoths would have required organized cooperation and the best in available technical equipment.

As with other proboscideans, the mammoth skeleton has vertical appendages that support the general mass of the animal; the capacity for oscillation at the top of the leg is weak (Hildebrand and Hurley, 1985), preventing proboscideans from running and jumping (Shoshani, 1993). Extant proboscideans can climb moderate slopes and cross mountainous regions, but for the most part they are not able to go up or down steep slopes. All these particularities would have played an important role in human hunting strategies.

Ethnographic data and travelers' tales from Central Africa include descriptions of tracking, killing and butchering elephants. The trails habitually used by elephants are easy to locate. Some African people dug pits or used spring-loaded spears on the trails, two methods which were most effective in regions with thick vegetation. Other people approached elephants closely and speared them, or hid in vegetation and injured an animal when it walked by (Thomas et al., 2011). One people in West Africa disguised themselves as animals and crawled towards elephants to surround them (Alpern, 1998).

Human groups could have chosen different hunting strategies, such as attacking a solitary male mammoth, isolating an individual from a mixed herd or going after an entire herd. To kill individuals on the spot, it would have been necessary to inflict several simultaneous attacks or mount an attack which caused the mammoth to charge while other hunters waited in ambush. Many spear-wounds might have been necessary to kill an individual, although Central African hunters once approached elephants very closely and stabbed them with a single spear jab, then allowed the wounded animal to run until it was exhausted or it died. When mixed herds of African elephants are confronted nowadays by hunters with high-powered rifles, the group is first approached on several flanks, causing herd members to regroup around the young with the matriarch facing the attackers. The matriarch is shot first, and as other individuals are killed their carcasses block others from running away, so all the herd can be killed together. Of course, this method was not available to mammoth hunters, but the killing of a family group's leader probably would have had a similar effect in a mammoth hunt, causing the rest of the group to mill about in confusion and make some of them easier to close in on and throw or thrust spears at them.

The evidence that mammoths were actively hunted is seldom obvious. However, hunting rather than scavenging has been demonstrated or suspected in several sites across Europe, practiced by different hominins. The evidence may be a direct association between projectiles and the bone remains such as point fragments embedded in bone or lying among the bones, or mortality profiles dominated by juveniles which would have been the most vulnerable age class, thus suggesting deliberate human choices of animals to kill, or the techno-typology of associated lithic artifacts which appear appropriate for killing and butchering proboscideans (Gaudzinski et al., 2005). The finds at Lehringen (Germany) attest that Middle Palaeolithic Neanderthals had wooden spears capable of killing ancient elephants. Hunting by Upper Palaeolithic *Homo sapiens* is strongly suggested by the mammoth bones at the Milovice site (Czech Republic; Péan, 2001) and Kraków Spadzista (Poland; Wojtal et al., 2015), where dozens of mammoths are represented in the faunal assemblages. Direct evidence of mammoth-killing in the Upper Palaeolithic is seen with the hunting lesions and projectile points embedded in bones at Yana RHS (Russia; Nikolskiy and Pitulko, 2013), Lugovskoe (Russia; Maschenko, 2004), Kraków Spadzista (Wojtal et al., 2019), Kostënki 14 (Russia; Sinitsyn et al., 2019) and Nikita Lake (Russia; Pitulko et al., 2016).

As with mammoths, the physical traces of butchering activities on extant elephantids can be scarce. Cut marks may be rare on bones because of the thickness of cartilage and periosteal tissue, effectively stopping sharp tool edges from penetrating to cortical bone surfaces (Haynes and Klimowicz, 2015). Crader (1983) recorded mostly heavy chop marks on recent elephant skeletons months after people had butchered them with metal tools. Only a few deposits testify to butchery activities on woolly mammoths (Péan and Patou-Mathis, 2003), such as La Cotte de St Brelade (Jersey) (Scott, 1980; Smith, 2015). Observations of butchering techniques on modern elephant carcasses have been described (Haynes, 1991; Jones, 1994; Haynes and Klimowicz, 2015). Butchering experiments by modern-day scientists (e.g., Toth and Schick, 1983; Jones, 1994) generally emphasize the difficulties and lengthy process of butchering an elephant. Jones (1994) suggested twenty people would need about two hours with fairly large tools to skin and strip meat from a proboscidean carcass.

The process when done by experienced butchers has been documented by Haynes (1991). Jones (1994) suggested this sequence (Fig. 7.2):

- the skin is removed from limbs, which can be done quickly by few people;
- the skin is removed from the torso and abdomen;
- several people remove large packages of muscle meat from limbs and ribs, while others cut off the ears and trunk;

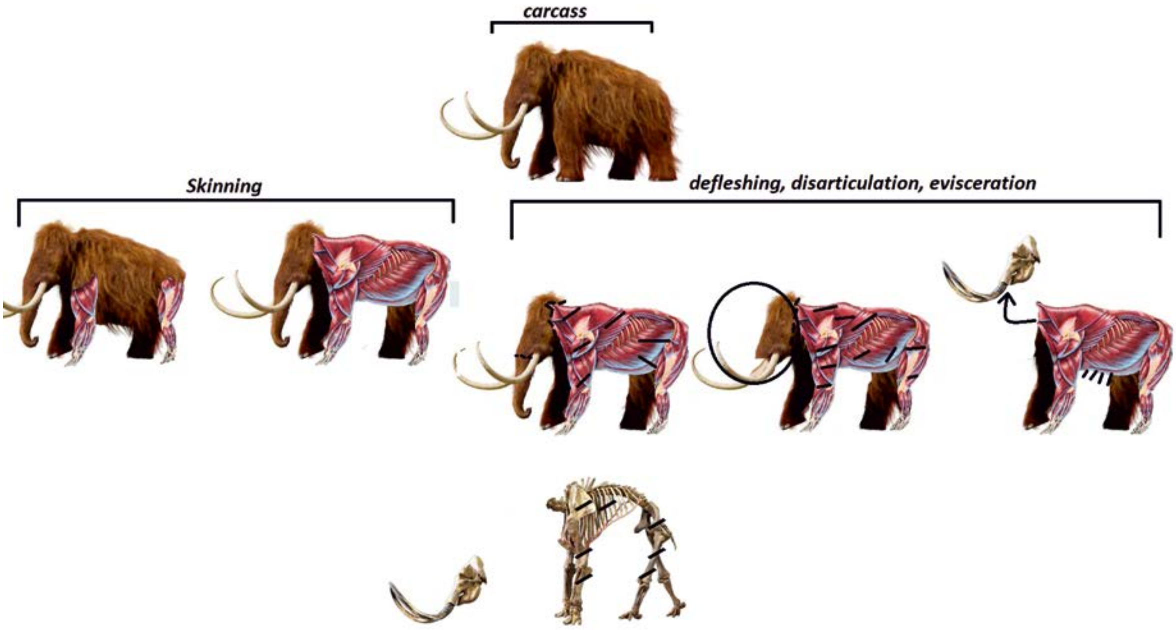


Figure 7.2: Representation of a *chaîne opératoire* of mammoth butchering (graphism and permission acquired from J. Demay)

- the head is rarely removed in modern butchery, but it can be removed with some hard cutting and chopping and then rolling it on itself.

Only one side of a carcass can be worked at a time. The carcass can be turned upside down by a group of butchers pulling on the legs with ropes while another part of the butchers push it on the other side; it is also possible to enter the open rib cage and butcher the downside of carcasses;

- remaining skin is removed, as well as remnant meat;
- the carcass is opened to recover the organs, in particular the stomach, taken in slices;
- all the scrap meat left on bones is scraped.

The meat and fat yields from full-grown adult mammoths are estimated at ~1800–2100 kg (Soffer, 1985; Davis and Reeves, 1990). Such a quantity of meat requires planned preservation treatment. Different processes are known with direct and indirect cooking, and for conservation.

Direct cooking could have been done several ways:
- grilling against hot coals;
- frying on a heated surface;
- roasting over an open fire;
- baking in a covered vessel;
- steaming.

Indirect cooking might have involved:
- boiling in water inside a vessel heated by hot stones;
- boiling in water inside a vessel placed on a fire;
- coating meat in clay and placing on a fire.

Preservation for future consumption might have involved:
- desiccation by air or sun;
- wood-smoking;
- pressing;
- coating meat in grease to keep bacteria or insects away;
- refrigeration and freezing;
- storing underwater;
- pounding the meat and drying it into a leather-like consistency.

Bones and grease could have been used to make bone broth or bouillon.

The management of ivory also involves specific actions (Heckel, 2009). Green ivory taken from a recently dead elephantid tends to shrink as it dries. The outer layers of fresh or fossil ivory can be softened by soaking in water or mild acidic compounds (Christensen, 1999). Tusks cannot be removed from fresh carcasses without chopping, but a few days after death the natural process of decomposition weakens the connective tissue of the incisive sockets and the tusks can be pulled out of the cranium. They can then be soaked in water for several days, weeks or months. Ivory can be shaped by breakage and by sawing after making longitudinal, transverse, and circular grooving. It is possible to obtain a glossy surface by polishing (Semenov, 1957; Khlopachev, 2006; Khlopachev and Girya, 2010; Pitulko et al., 2015).

7.2.4. UNIQUE FACTORS IN ZOOARCHAEOLOGICAL AND TAPHONOMIC STUDIES OF MAMMOTH REMAINS

A taphonomic analysis of mammoth bone assemblages encounters particular problems. Cut marks are not common on butchered mammoth remains (Crader, 1983), making it difficult or impossible to determine butchering practices. Kill sites or scavenged carcass sites may have been used as camps, making it difficult to distinguish whether humans hunted mammoths or made use of natural bone accumulations.

Active hunting is often claimed on the basis of mortality profiles (Haynes, 1991, 2017), but without direct traces. It is likely that many times only mammoth meat from hunted animals was brought to campsites and no bones are present to show that hunting was done thus (Bocherens et al., 2005).

Proboscidean remains may be affected by taphonomic processes such as traumatic injuries to bones (Haynes and Klimowicz, 2014) or natural breakage of ivory during use in life or while fighting conspecifics (Haynes, 1991), which could be confused with human actions. Another possibly complicating factor in interpreting proboscidean bone assemblages is the behavior of proboscidean individuals which displace bones of dead conspecifics.

7.2.5. HISTORIOGRAPHY

Mammoths have a special place in studies of Palaeolithic human populations in the East European Plain. Indeed, the first palaeolithic excavations discovered important sites containing not only abundant remains of mammoths, including some apparently used to construct multi-family dwellings, but also osseous artifacts and carefully shaped ivory pieces, such as Gontsy in 1871 (Scherbakivski, 1919), Kostёnki in 1879 (Boriskovskyi, 1953), Kirillivska in 1893 (Khvoiko, 1913) and Mezin in 1907 (Shovkoplias, 1965).

Historical contexts and geopolitical implications played important roles in the interpretations of these discoveries (Miller, 1956; Soffer, 1985). Finds of presumed communal dwellings seemed to reinforce the validity of the palaeoethnological approach, which had developed under the influence of Marxism. However, some of the features thought to be dwellings now have been questioned, although the discoveries did inspire a pluridisciplinary approach to excavations and analysis with new methods such as taphonomy, which had been considerably restrained during the Cold War.

7.3 PROBLEM STATEMENT, MATERIALS AND METHODS

7.3.1. RESEARCH OBJECTIVES

Our aim is to better estimate the place and the use of mammoth during Palaeolithic and to work again with this pluridisciplinary approach.

From old and new excavation materials, we need to better determine better the conditions of burial, and the modalities of acquisition and use of mammoth resources by humans, and to better apprehend the status of mammoth, among other species, according to the areas and periods, in order to highlight evolution of human behaviors.

7.3.2. MATERIALS AND METHODS

First we specify the representation of the mammoth in relation to other species within archaeological assemblages, both in quantitative terms and in terms of use. Based on analysis of data from previous work we discuss the representativeness of the different species in archaeological assemblages, and we also take into consideration the techno-cultural complexes in order to determine the type of occupation and the type of hard materials of animal origin that could have been used.

The zooarchaeological approach is favored here, including palaeontological analyses. The description and quantitative analysis of anatomical elements affected by climate, edaphic factors and non-human biological agents make it possible to clarify the origins of fossil assemblages. These analyses in relation to the marks left by humans lead to a better understanding of the anthropogenic impact on the assemblage (Binford, 1979; Lyman, 2008; Denys and Patou-Mathis, 2014). Age and sex determinations of mammoth individuals are based on well-known Eurasian specimens and data from Haynes (1991). The age classes of mammoths (in Laws 1966 groups) are as follows:

- juvenile: stage I–IXa; 0–12 years old
- young adult: stages IXa–XVII; 12–25 years old
- intermediate adult: stages XVII–XVIIIa; 25–30 years old
- mature adult: stages XVIIIa–XXVI; 30–50 years old
- old adult: stages XXVI–XXX death; 50–60+ years old

Mortality profiles patterns of mammoths are used to infer the origins of assemblages (Haynes, 1991). Type A includes progressively decreasing proportions of successively older age categories. It is seen in some noncultural assemblages as a nonselective mortality in stable populations. Type B contains a large proportion of youngest individuals, very few prime-age and middle-aged adults but relatively more old adults. It is seen in larger cultural assemblages as resulting from selectivive mortality events. Type C contains mostly prime-aged individuals and few very young and old individuals. It is possible that this type is the result of a different kind of selective mortality. Type D includes any shape other than these three.

All archaeological and faunal data, and references about the sites dated between 30,000 and 10,000 BP were synthesized in Demay (2017).

Concerning statistics, the adjusted residuals are the adjusted values (or the difference between the observed accounts and the expected accounts) divided by an estimate of the standard error. They allow variations due to differences in size between samples to be taken into account. Thus, it is possible to highlight the influence of each species on all of the samples.

7.4 RESULTS

We present data about Middle and Upper Palaeolithic sites. During these periods, mammoths are well represented in the East European Plain (Klein, 1973; Hoffecker, 2002), particularly in the plain (Vereshchagin and Kuzmina, 1977; Soffer, 1985) and some sites of the extracarpatic area in the Dniester and Prut valleys (Borziac and Obăda, 1999; Anisiutkin, 2003–2004).

7.4.1. THE MIDDLE PALAEOLITHIC

During the Middle Palaeolithic, four archaeological sites present important mammoth remains: Ketrosy, Ripiceni-Izvor, and Molodova I and V (Fig. 7.3).

Figure 7.3: Middle Palaeolithic sites with significant mammoth assemblages. 1, Ketrosy; 2, Ripiceni-Izvor; 3, Molodova I and V.

The main layer (3) of Ketrosy is dated to ~100,000 BP (Cârciumaru, 1980; Stepanchuk and Sapozhnikov, 2010; Anisiutkin, 2013). This layer, excavated on 125 m², was 5–25 cm thick and furnished charcoals and burnt charcoals, as well as ocre and 4000 lithic pieces.

The lithic industry is represented by nucleus and tools made on local and regional flint (pebbles and slabs) and is linked to typical Mousterian. The fauna is represented by ~500 bone remains belonging to mammoth (110 bones), bison, horse, marmot, woolly rhinoceros, bear and a large cervid (David, 1980). Some mammoth limb bones bear apparent cut marks (David, 1980). A semicircular accumulation of over 12 m² of large mammoth bones and tusks with a hearth and ochre inside and with large stones was found. The outer side was facing north and the interior one south. Tools were around the accumulation and lithic wastes of debitage were in other sectors of the camp. This accumulation was interpreted as a windscreen.

Layer 4 of Ripiceni-Izvoris, dated >45,500 BP, yielded ~36,000 lithics and numerous hearths (Păunescu, 1993; Doboş and Trinkaus, 2012). Faunal remains are abundant, mainly from mammoth, bison, giant deer and red deer. Moreover, subcircular areas containing mammoth tusks, bones, molars and rocks were interpreted as windscreens and habitation structures.

Layer 4 of Molodova I (1,200 m²), was excavated by A.P. Chernysh, is dated to a minimum age of >44,000 BP (Goretsky and Ivanova, 1982). It yielded many finds including 26 hearths, ocre, lithic tools and faunal remains. The inventory consists of 40,000 flint pieces, which are characteristic of typical Mousterian without bifacial form, with rare Quina elements. There are nuclei and tools coming from local deposits, mainly made for butchering and hunting activities. Five areas of activities were discovered: a pit with bones, an area with bones, which bear on-food parallel striations and ochre, two areas with accumulations of lithic flakes and bones, and a circular accumulation of bones. This bone accumulation was interpreted in different ways, including as a dwelling structure. The fauna is quite diversified and dominated by mammoth. We conducted a zooarchaeological study (Demay et al., 2012) and identified different large herbivores (mainly mammoth, but also red deer, bison, reindeer, horse and woolly rhinoceros), as well as carnivores (fox, wolf, leopard). The mammoth mortality profile is characterized by the presence of adults *sensu lato* (both males and females) and juveniles, and is more related to a slaughtering profile. Moreover, according to the taphonomy we highlighted two modalities of bone preservation, which could be related also to dry bone gathering. Mammoth bones bear marks of human activities, such as cut marks, breaking impacts, and series of grooves not related to food activities (Fig. 7.4). Concerning the circular bone accumulation, particular bones were selected, with different areas of activities inside, corresponding to a living space (Fig. 7.5). Therefore, this layer could correspond to a long-term camp or to repeated occupations, with exploitation of secondary game and mammoth as main game, for food, as technical support, and use of bones to make a structure, which can be interpreted as a windscreen (Fig. 7.6).

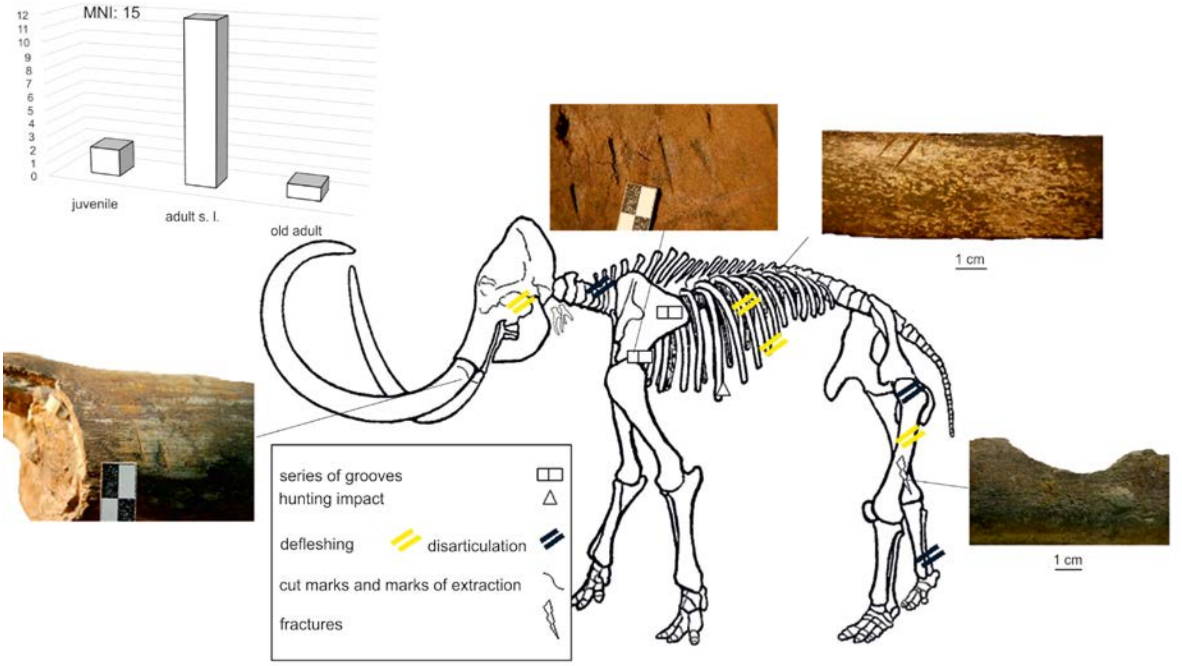
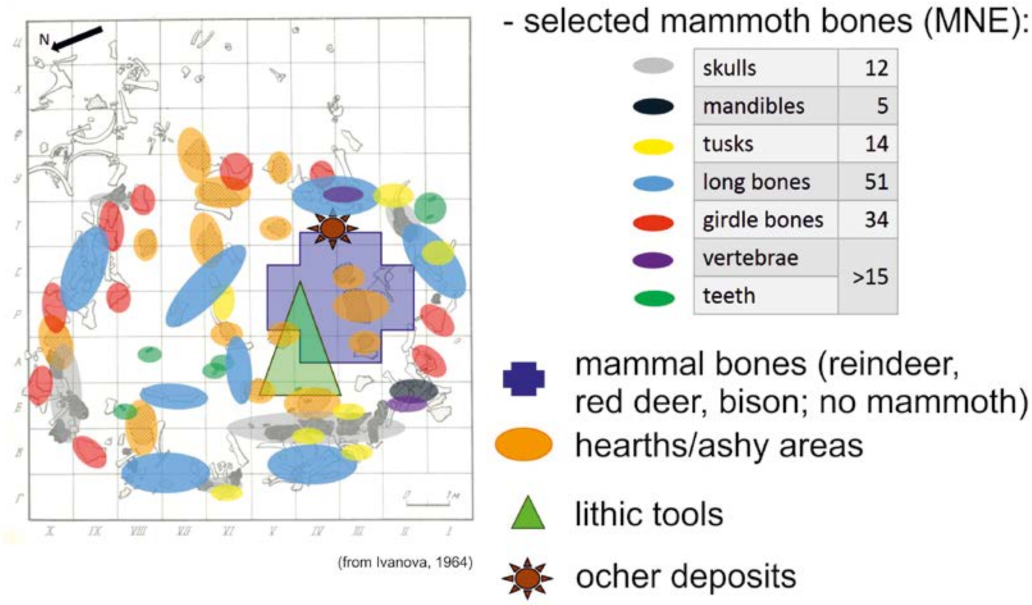


Figure 7.4: Mammoths mortality profile and bone modifications by humans in Molodova I/4 (Ukraine).



(from Ivanova, 1964)

- selected mammoth bones (MNE):

●	skulls	12
●	mandibles	5
●	tusks	14
●	long bones	51
●	girdle bones	34
●	vertebrae	>15
●	teeth	

Figure 7.5: Circular accumulation of mammoth bones in Molodova I/4 (Ukraine) and spatial distribution of other archaeological remains (modified from Ivanova, 1964 in Goretsky and Ivanova, 1982).

Layer 11 of Molodova V (900 m²) was dated to >45,600 BP (Chernysh, 1987). The lithic industry is attributed to Levallois-Mousterian industry. The sedimentary context is difficult to understand, but this layer potentially could be correlated to ~MIS 5 (Ivanova and Tzeitlin, 1987; Haesaerts et al., 2003). The mammalian fauna is composed of woolly mammoth, woolly rhinoceros, reindeer, bison, horse, red deer, cave lion and brown bear, (Chernysh, 1959). Mammoths were notably ma-

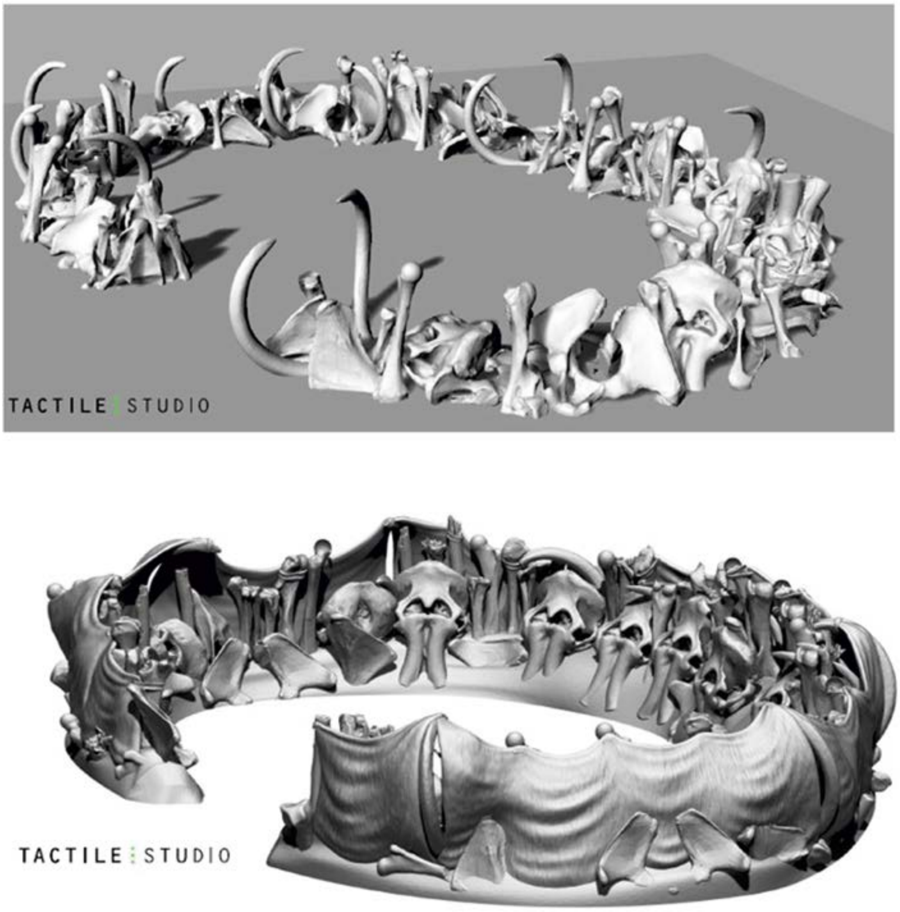


Figure 7.6: Hypothetical reconstruction of the windscreen at Molodova I/4 (Ukraine) (reproduced with permission acquired from Tactile Studio).

ture adults and according to A.P. Chernysh they were hunted.

According to these sites, mammoth carcasses were obtained by Neanderthals through hunting and gathering, for food and non-food utilization. Mammoths were used as building material to make windscreens. This pratice is a very specific techno-cultural fact of this region.

7.4.2. THE UPPER PALAEOLITHIC

Concerning the Upper Palaeolithic, there are few Aurignacian sites. The proto-Gravettian site of Kostënki 14, dated to ~35,000 BP, furnished an ivory point embedded in a mammoth rib (Sinitsyn et al., 2019).

In Buran-Kaya III, results obtained from isotopic analyses of the materiel from the Upper Palaeolithic layers, dated between 35,000 and 30,000 BP, show that humans consumed mammoth meat (Drucker et al., 2017).

Many sites dated between 30,000 and 10,000 BP are known, correlated to the Gravettian, Epi-aurignacian, Epigravettian and final Palaeolithic (Fig. 7.7).

MAMMOTH IN UPPER PALAEOLITHIC ARCHAEOLOGICAL SITES | Of the 250 Upper Palaeolithic assemblages, 229 contained faunal remains (92%). Mammoths are present in 135 of them (59%) and are the dominant species in 51 assemblages (38%).

Concerning the sites between 28,000 and 23,000 BP, correlated to the Gravettian, mammoth is dominant in several of them, notably in Berdyzh (Stepanchuk and Cohen, 2000–2001) and Yurovichi (Soffer, 1985). In some sites, such as in Krakòw

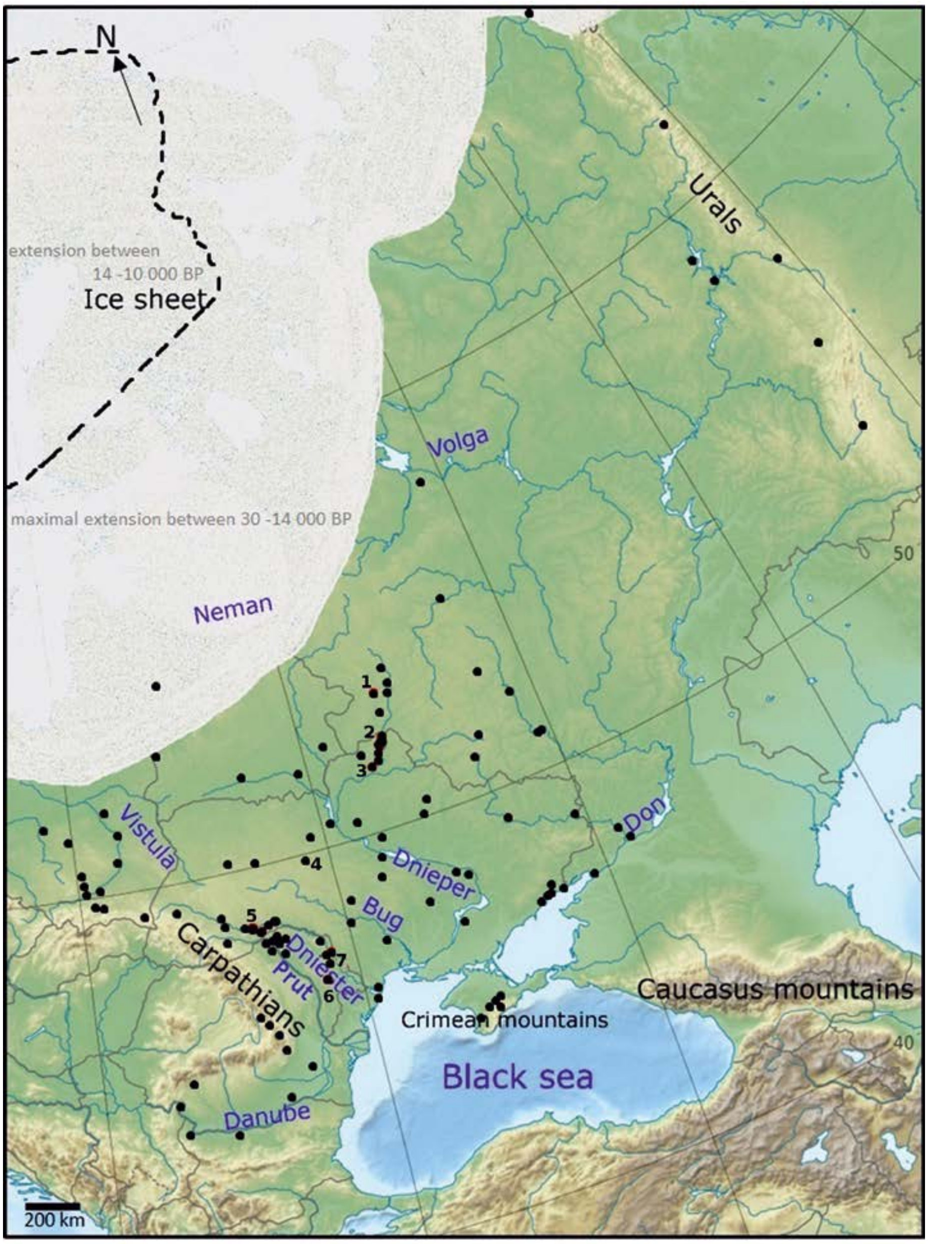


Figure 7.7: Geographic position of the main archaeological sites of the East European Plain dating between 30,000 and 10,000 BP. Sites mentioned in the text: 1, Eliseevichi 1; 2, Pushkari group; 3, Obollonia; 4, Radomysh'l; 5, Dorochivtsy III; 6, Valea Morilor; 7, Climăuţi II.

Spadzista with flint tools embedded in two ribs; Wojtal et al., 2019; Haynes, pers. data) and Galich 1 (Wojtal et al., 2001), mammoths were hunted and butchered. In Khotylevo, ivory was used to make female statuettes and mammoth ribs were intentionally put vertically in small pits (Velichko et al., 1981; Soffer, 1985). In Sungir, ivory was used to make ornaments (pearl, ivory rings) and tools (assegais), which are associated with human skeletons in three burials (Bader, 1978; Abramova, 1995; Trinkaus et al., 2014) (Fig. 7.8).

During the LGM (23,000–20,000 BP), mammoth is dominant in several sites, and ivory was used for female and animal statuettes: Avdeevo (Gvozdover, 1995), Gagarino (Tarasov, 1969) and Zaraïsk (Amirkhanov et al., 2009). In Kostënki 1, an accumulation of tusks could correspond to a dwelling structure and/or tusk storage (Lazukov, 1957). In Kostënki 11, a dwelling structure with mammoth bones was discovered (Rogachev, 1966). At Kostënki 21, mammoth calves and adult mammoths were hunted

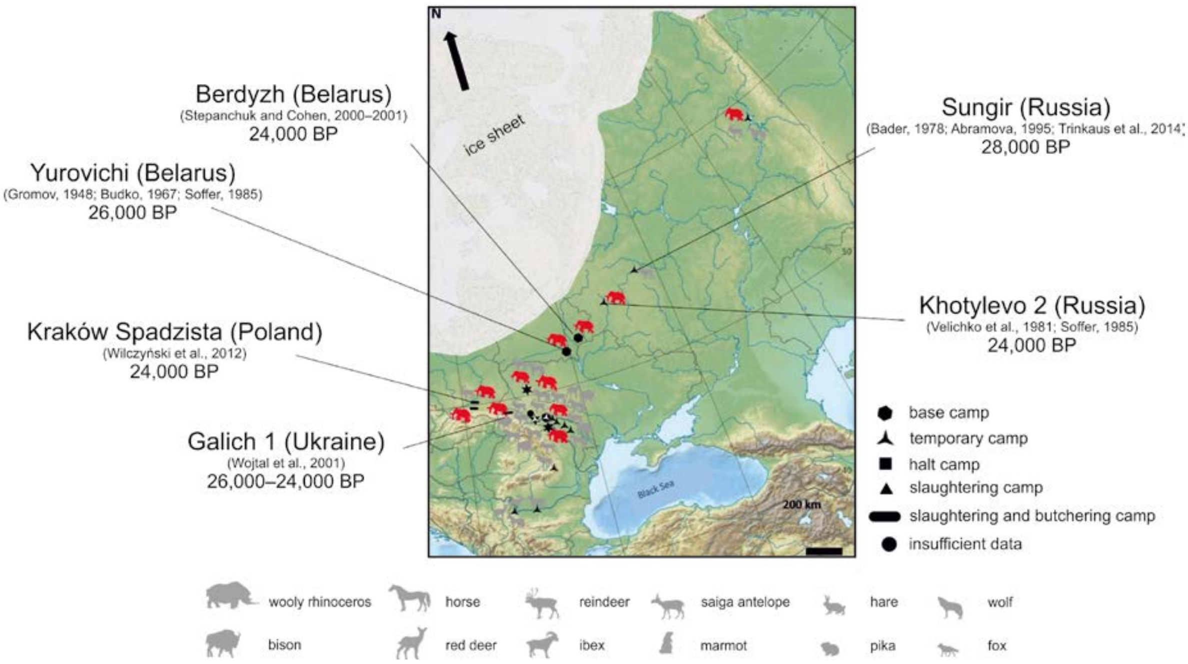


Figure 7.8: Main archaeological sites in the East European Plain dating between 28,000 and 23,000 BP, types of occupations, fauna and mammoth resource exploitation (in red).

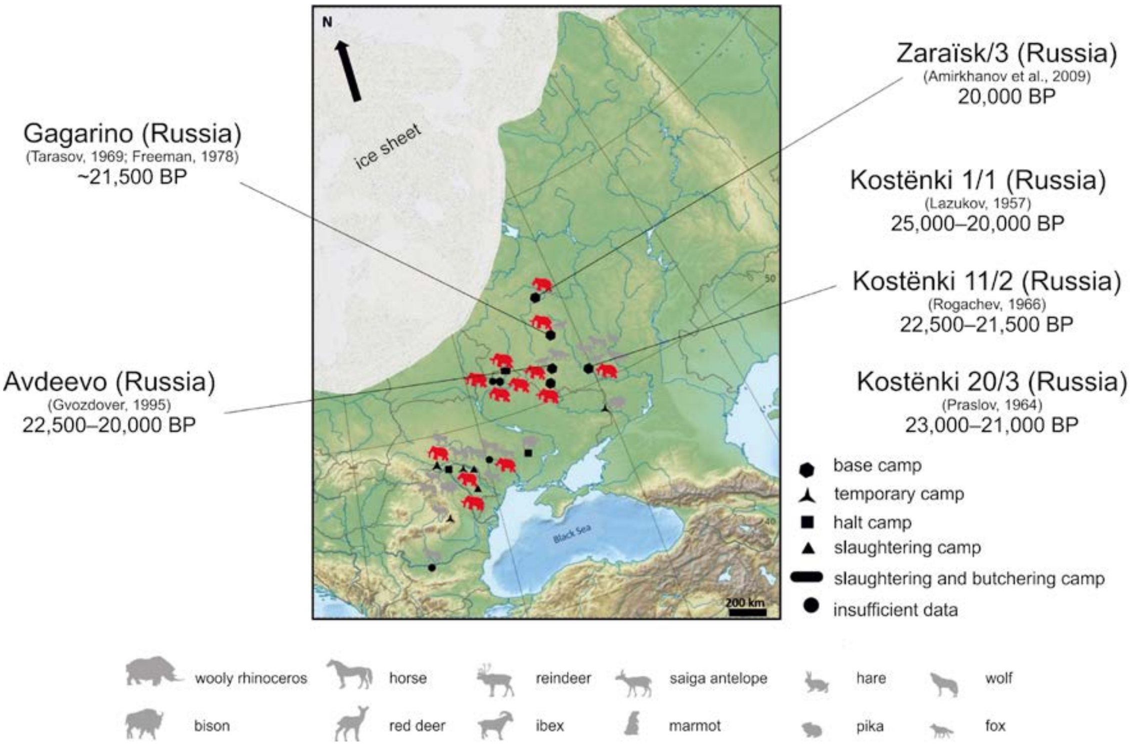


Figure 7.9: Main archaeological sites in the East European Plain between 23,000 and 20,000 BP, types of occupations, fauna and mammoth resource exploitation (in red).

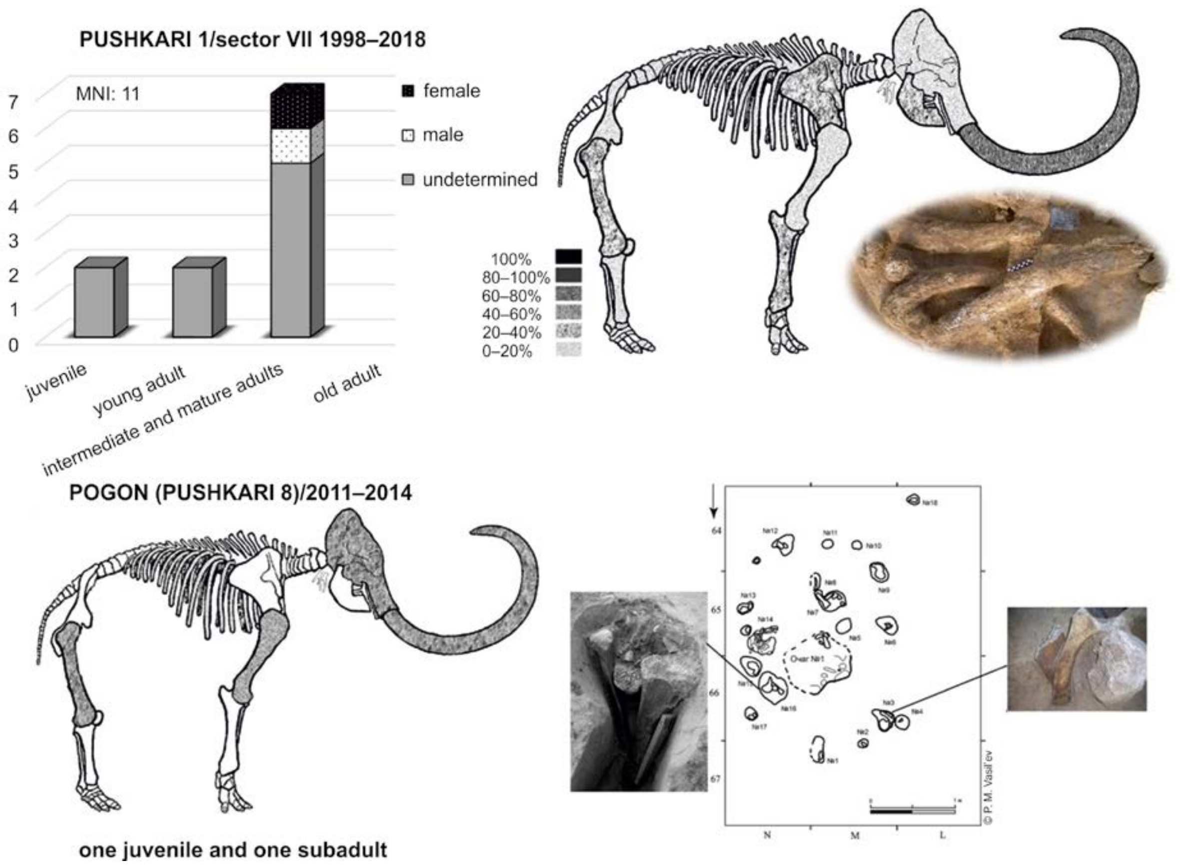


Figure 7.10: Mammoth mortality profile, representation in percentage survivorship and bone exploitation in Pushkari group (Pushkari 1 and 8-Pogon; Ukraine): tusk storage and bones put vertically in pits around fireplace (permission acquired from P. M. Vasil'ev).

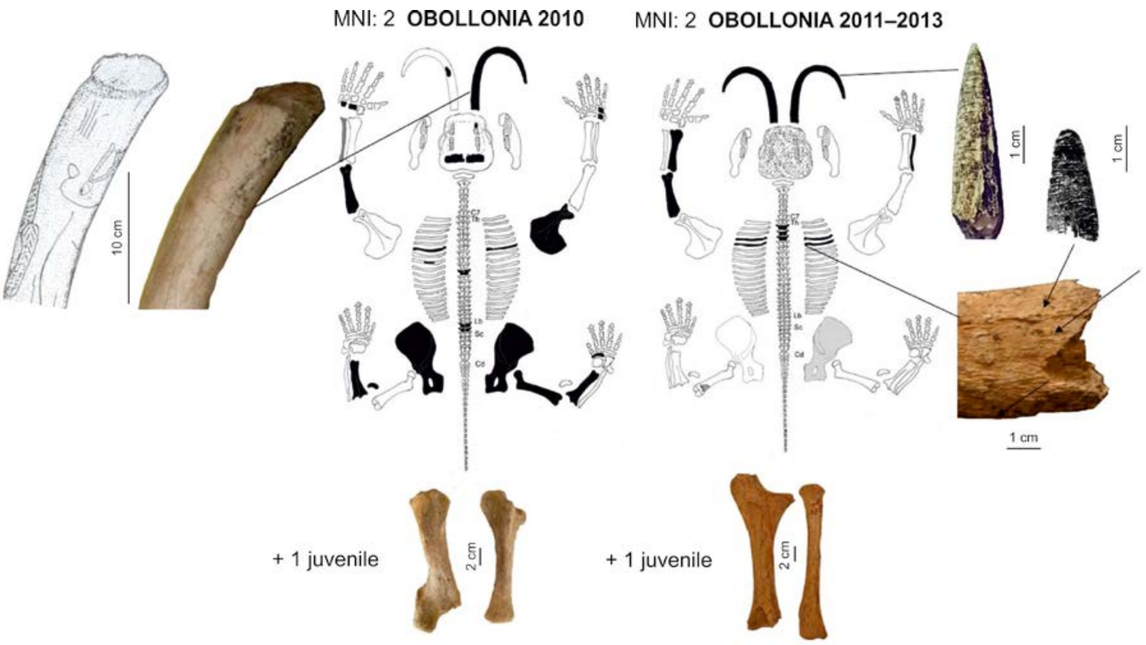


Figure 7.11: Skeletal preservation of adult mammoths (composite representation), and bone and tusk exploitation in Obollonia (Ukraine): engraved tusk, ivory points and rib with defleshing cut marks; bones of juveniles. Schematic drawing of the skeleton by C. Camaret.

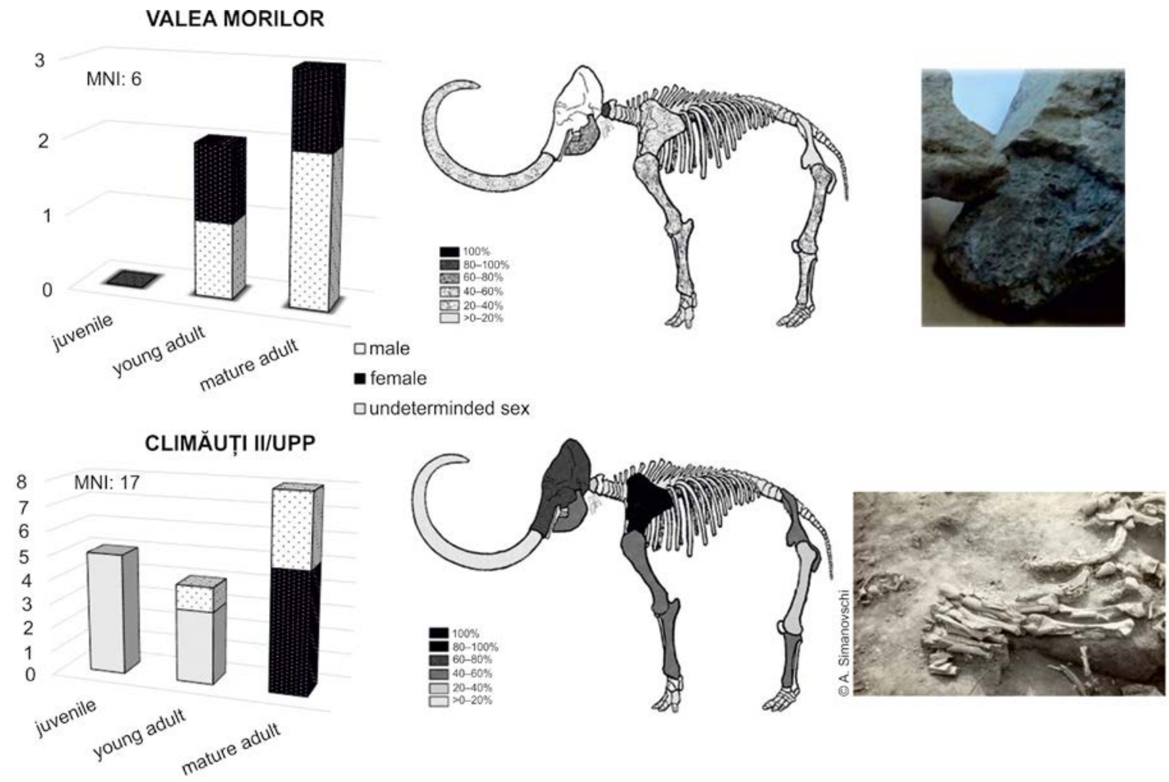


Figure 7.12: Mammoth mortality profiles, percentage survivorship and bone exploitation in Valea Morilor and Climăuţi II (Republic of Moldova): burnt bone and sorted mammoth bones (permission acquired from A. Simanovschi).

(Fig. 7.9; Reynolds et al., 2019; Germonpré et al., this volume).

A set recent investigations has focused on LGM sites, notably in the Dniester and Desna valleys in Ukraine: Pushkari 1, Pogon (Pushkari 8), Obollonia (Demay et al., 2016) and Dorochivtsy III (Demay et al., 2015); and in Republic of Moldova: Valea Morilor (Demay et al., 2019) and Climăuţi II (Demay et al., in press).

In Pushkari 1 and Pogon, the faunal spectrum is similar to other sites, dominated by mammoth and followed by canids (fox and wolf), horse and reindeer. In Pushkari 1, the mammoth mortality profile suggests hunting by humans; tusks are overrepresented and put together, probably due to intentional storage. In Pogon, bones were stored vertically in pits around a hearth, perhaps as a wedging structure (Fig. 7.10).

In Obollonia, mammoth is the dominant taxon and is associated with some bone remains of carnivores (fox and bear). In Obollonia, mammoth was butchered and ivory was used to make points and a tusk was engraved (Fig. 7.11).

In Valea Morilor, mammoth bones were used as combustible fuel. For Obadă et al. (2012), a small structure with mammoth bones was present. In Climăuţi II, mammoths were hunted and the bones were sorted by type of element, and put circularly around a hearth and a small pit (Borziac et al., 2007; Fig. 7.12).

Between 20,000 and 14,000 BP, numerous sites are known. Mammoth is dominant mainly in sites of the plain, in some cases with a high number of individuals (up to a hundred), mainly young and mature adults, and followed by juveniles. Mammoths were mostly hunted and butchered as in the case of Yudinovo (Germonpré et al., 2008). Otherwise, several sites are characterized by the use of mammoth bones to make dwelling structure, such as in Mezhirich, Mezin and Gontsy. In all these latter sites, ivory was used to make tools, needles, ornaments and portable art (Fig. 7.13).

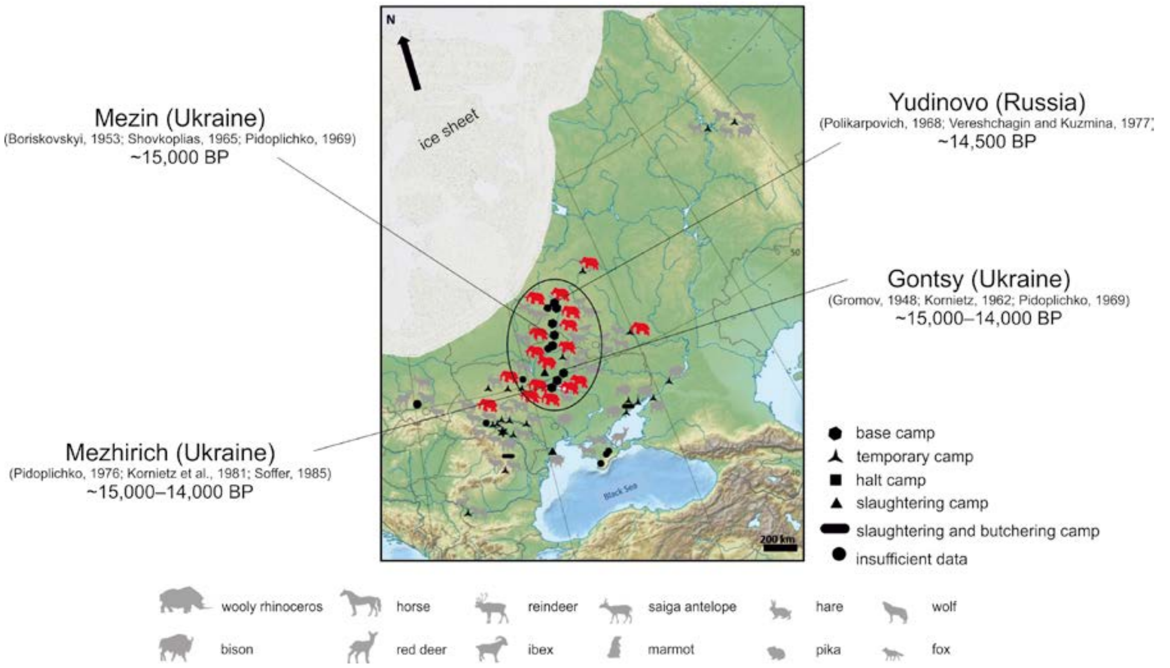


Figure 7.13: Main archaeological sites in the East European Plain between 20,000 and 14,000 BP, types of occupations, fauna and mammoth resource exploitation (in red).

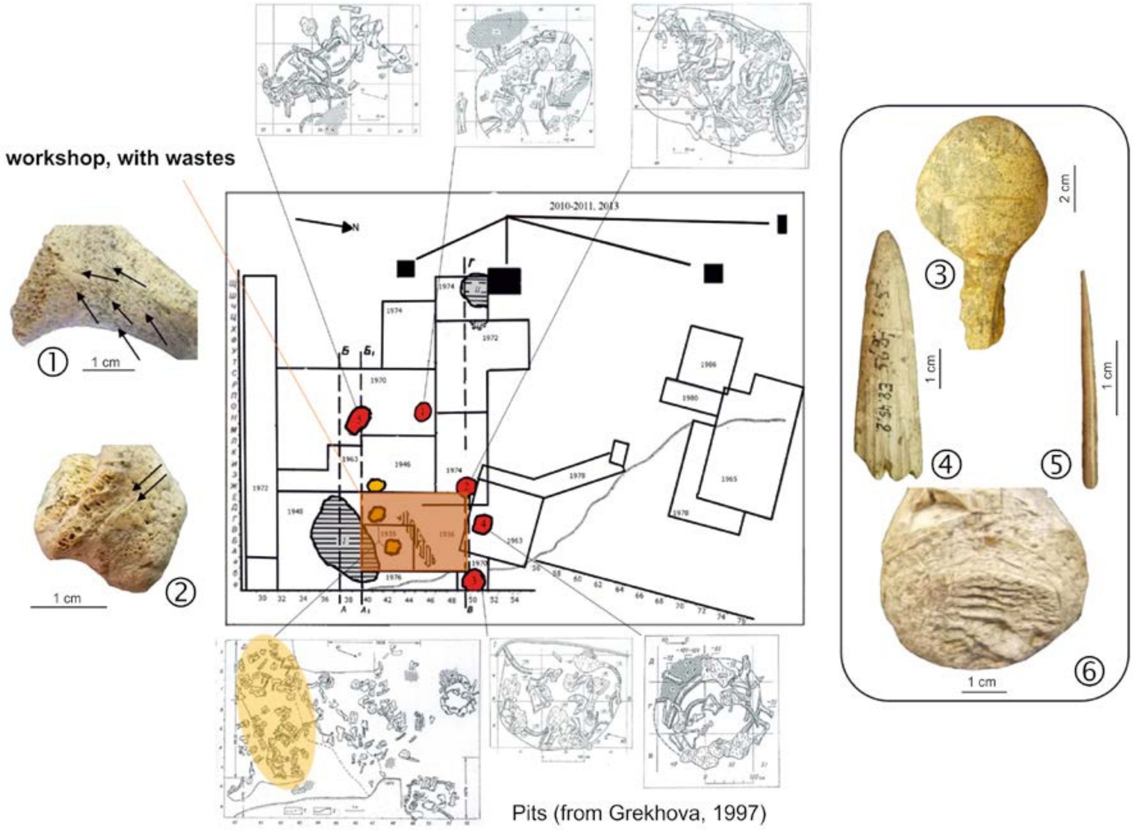


Figure 7.14: Interpretation of the spatial distribution in Eliseevichi 1 (Russia) linked to mammoth resource exploitation: 1, juvenile rib with cut marks; 2, adult phalanx with cut marks; 3, ivory piece; 4, ivory point; 5, needle; 6, conical transverse grooving on tusk. Spatial distribution maps from Grekhova in Velichko et al. (1997).

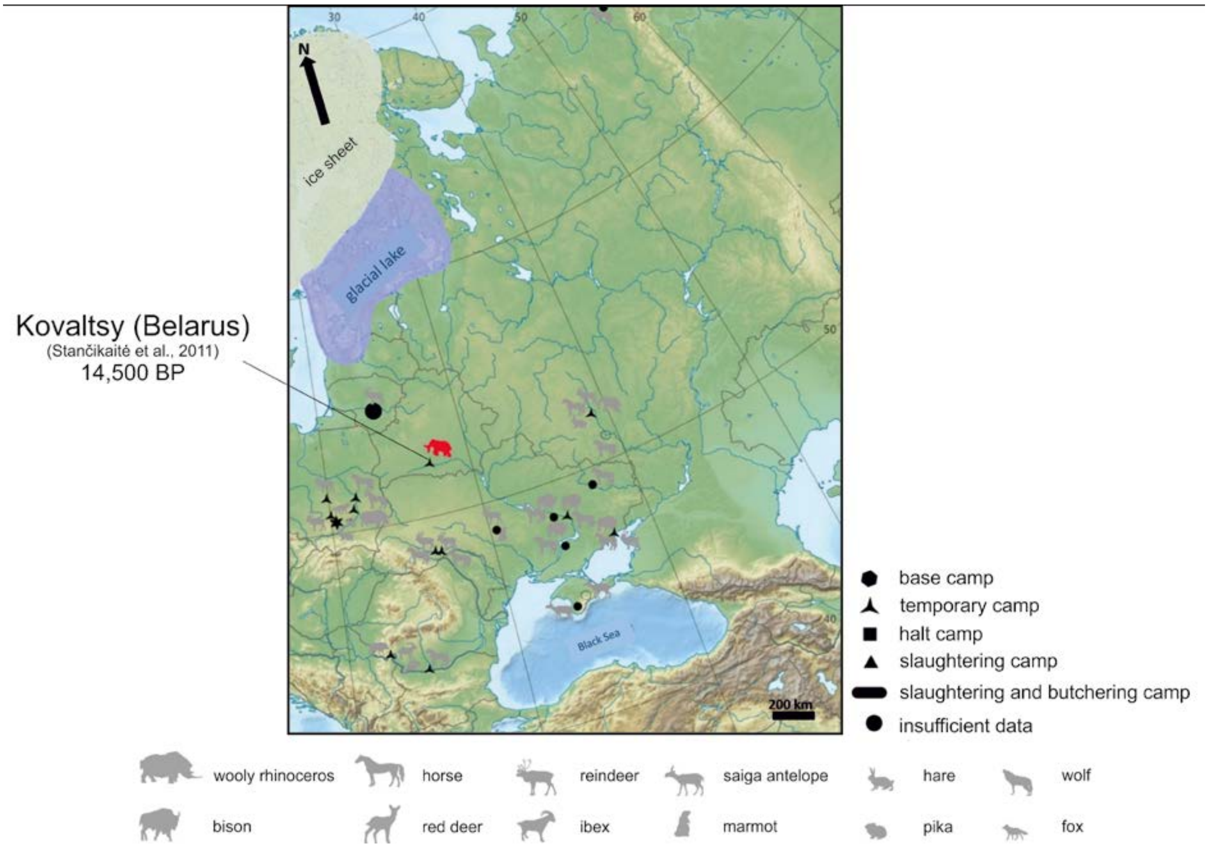


Figure 7.15: Main archaeological sites in the East European Plain between 14,000 and 10,000 BP, types of occupations, fauna and mammoth resource exploitation.

In contrast, recent research, such as in Radomysh'l, indicate that some mammoth bone accumulations are not remains of dwelling structure (Kononenko et al., 2006). In Eliseevichi 1 (Russia; Velichko et al., 1997), even if mammoth status was significant, canids (wolf and fox) were also important, in terms of number of specimens, and both skinning activities and bone shaping. Mammoths are represented mainly by adults and are followed by juveniles, whose bones bear also butchering cut marks. A part of mammoth bones were more altered, so they appear more ancient than other mammoth bones. Ivory was shaped to make tools and portable pieces. The first interpretations of pits with mammoth bones as dwelling structures were questioned. Indeed, the pits could be storage facilities for ivory (Demay et al., 2017; Fig. 7.14).

At the end of the Upper Pleistocene, between 14,000 and 10,000 BP, all the cold adapted fauna decreased, as a result of the climatic change. Mammoth is still dominant in Kovaltsy (Fig. 7.15). The last mammoth remains are known in Bugorok (Pushkari 9; Khlopachev, 2008).

USE OF HARD MATTERS | In Kostënki 18, a human child skeleton placed on its side in a flexed position was covered with mammoth bones (notably a scapula). It was interpreted as a burial, correlated to the Gravettian complex of Kostënki-Avdeevo during the LGM; however, the lack of shaped pieces and the stratigraphy of the site place some doubt on this interpretation (Klein, 1969).

Mammoth bones were used as support construction by the Gravettian and mainly by the Epigravettian humans in the plain. Bones mainly of adults were sorted and organized in a circular

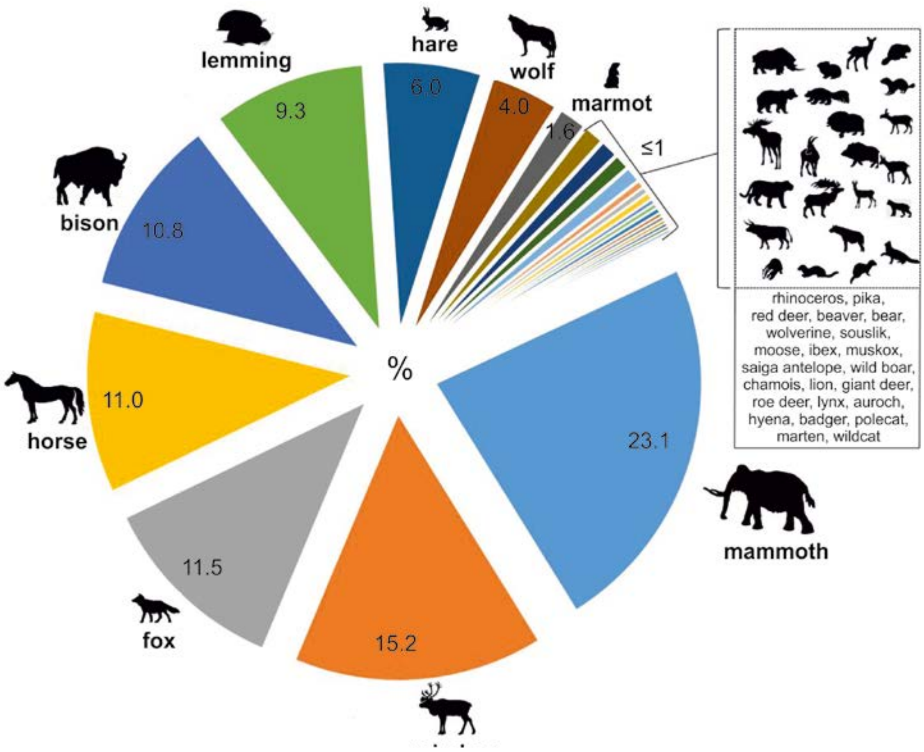


Figure 7.16: Faunal spectrum in percentages of the Minimum Number of Individuals in the main archaeological sites studied here from the East European Plain dating between 30,000 and 10,000 BP (5014 individuals in total).

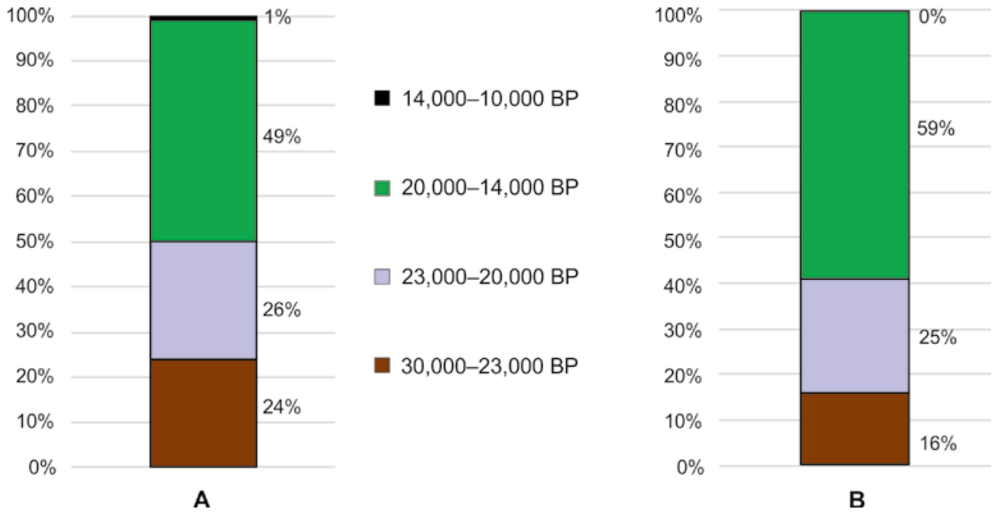


Figure 7.17: Percentage of the number of archaeological sites, among the total number of sites, by periods, according to: **A,** presence of mammoths; **B,** presence of mammoth worked bones.

manner. The taphonomic data show that fresh carcass bones and gathered dry bones were used. Mammoth bones were used as portable support, particularly reindeer antler, and bones of hare, fox and birds. Concerning mammoth bones, we could only consider the number of occurences, because of the difficulties to calculate the exact number of pieces. Ornaments were counted as artistic pieces.

Of the 135 assemblages with mammoth remains, 56 (41%) are characterized by the presence of mobiliary pieces made on mammoth bones and ivory. Of these 56 assemblages, 71% contain an osseous industry and 61 % contain artistic pieces.

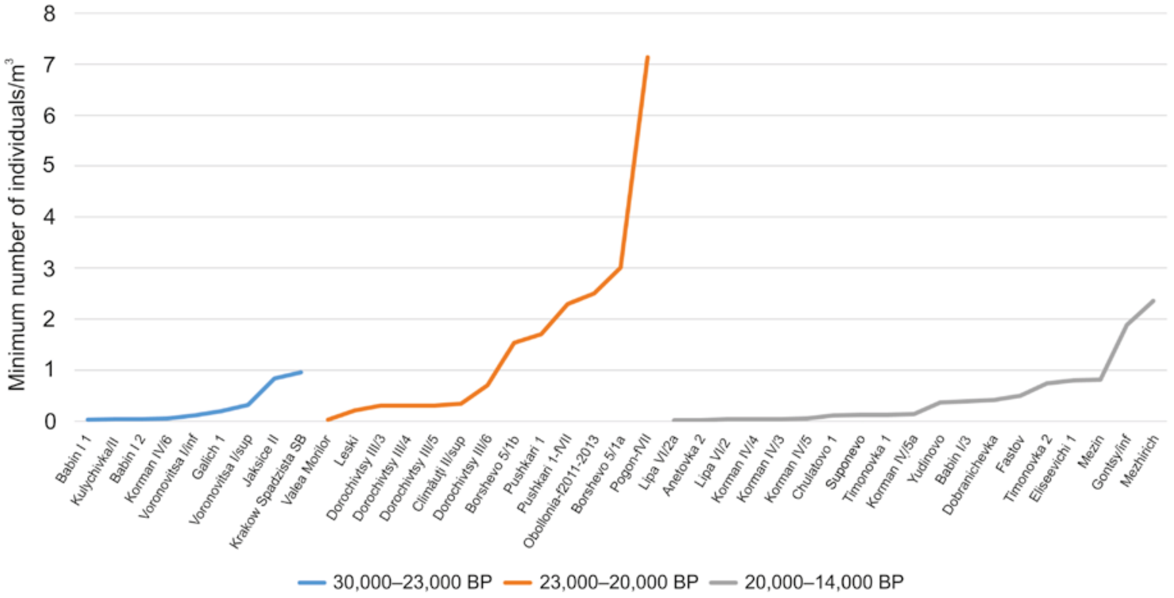


Figure 7.18: Density of mammoth in archaeological sites according to the Minimum Number of Individuals in m3 in the East European Plain between 30,000 and 14,000 BP, by periods.

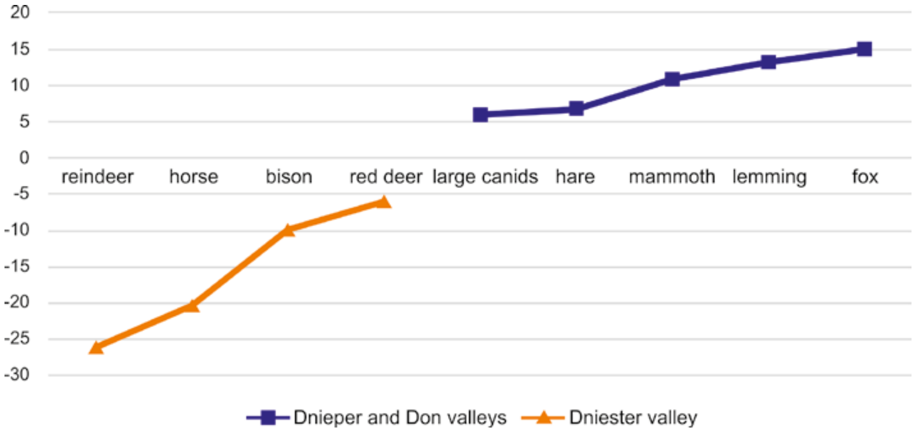


Figure 7.19: Adjusted residuals of the main taxa present in archaeological sites of the East European Plain according to the number of individuals between 30,000 and 10,000 BP, by areas (total: 27 taxa; 3,827 individuals, 78 archaeological assemblages).

Both osseous industry and artistic pieces are present together in 34 % of the assemblages. 21 sites (38%) present only osseous industry and 16 sites (29%) only artistic pieces. The main material used is ivory (93%), followed by bone (14%). The majority of the sites (86%) are characterized by the exploitation only of ivory, whereas exploitation only of bone is recorded in only few sites (5%). Both ivory and bone together were used in 9% of the sites.

Mammoth bones, including ribs, were used as combustible material in several sites, including Krakòw Spadzista (Wojtal et al., 2015) and Mezhyrich (Péan, 2015), both correlated to the LGM (Demay et al., 2016).

MAMMOTH IN ART | Among other species (woolly rhinoceros, bison, horse, cave lion, bear, wolf, caprines, birds and human), woolly mammoth is one of the most represented species. It is documented by sculptures, engravings and paintings (Abramova, 1995; Braun and Palombo, 2012). In the East European Plain, nine archaeological sites furnished mammoth representations: an

Figure 7.20: Worked ivory fragment from Climăuţi II/upper (Republic of Moldova).

engraving on schist in Kostënki 21 (Abramova, 1995), sandstone and bone sculptures in Avdeevo (Gvozdover, 1995), a sculpture from calcareous concretion in Eliseevichi 1 (Grekhova, 1980), an ivory sculpture in Sungir (Abramova, 1995), marl sculptures in Kostënki 1 (Cook, 2013), IV and XI (Abramova, 1995), red ochre paintings and engravings in Kapova (Abramov et al., 1984), and red ochre paintings in Ignatievska (Petrin, 1992). Other doubts exist concerning potential representation of mammoth: an engraved mammoth on a ivory piece in the Desna valley and a tiny marl statuette in Barmaki.

7.4.3. IMPORTANCE OF WOOLLY MAMMOTH FOR NEANDERTHALS AND ANATOMICALLY MODERN HUMANS POPULATIONS

We do not have enough data about the Middle Palaeolithic and the beginning of the Upper Palaeolithic, but we have more information concerning the period between 30,000 and 10,000 BP. Taking in account all the faunal spectrum about this period (Fig. 7.16), mammoth is the dominant mammal, closely followed by reindeer, then by fox, horse, bison, lemmings, hare, wolf and marmot, and lastly by other species (woolly rhinoceros, pika, red deer, bear, muskox, wolverine, moose, wild boar, ibex, beaver, suslik, cave lion, giant deer, saiga antelope, chamois, roe deer, aurochs, lynx, badger, polecat, marten, wildcat and hyaena). Mammoth bones and mammoth worked bones are more common in archaeological sites, between 20,000 and 14,000 BP (Fig. 7.17). Looking at each site by period, mammoth is well represented during the LGM (Fig. 7.18).

Using a statistical approach, within the entire faunal spectrum and throughout the studied period, mammoth, reindeer, horse, bison, canids and lagomorphs were the mammals mainly exploited. According to the comparative analyses (Fig. 7.19), we observe a continuous division of the representation of certain species according to the geographical zones: mammoth and canids in the plain (Dnieper and Don valleys), reindeer and horse in the extra-carpatic zone (Dniester valley).

Even if mammoth is less represented in the Dniester valley, ivory was used during all the Upper Palaeolithic, for example in Molodova V/8 (Chernysh, 1961), Cosăuţi/3a-3b-3c (Borziac et al., 1998), Dorochivtsy III/6 (Koulakovska et al., 2012; Demay et al., 2015) and Climăuţi II/upper with high technical expertise (Fig. 7.20).

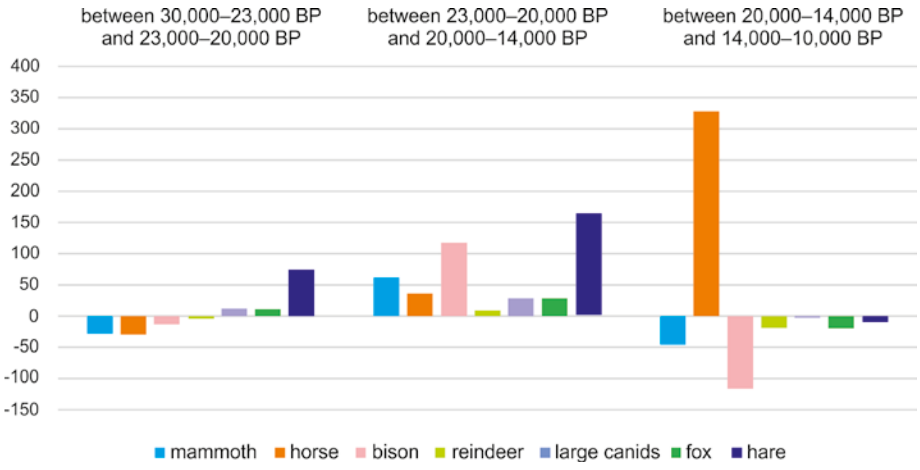


Figure 7.21: Adjusted residuals of the main taxa present in archaeological sites of the East European Plain according to the number of remains between 30,000 and 10,000 BP, by periods (total: 33 taxa; 239,409 remains; 121 archaeological assemblages).

Regarding the main exploited species during all the studied period, mammoth was exploited during all the Upper Palaeolithic. As we noted in discussing the sites, mammoth was also exploited during the Last Glacial Maximum. During the second part of the Upper Pleniglacial, we observe an intensification of the exploitation of taxa in quantitative terms, even for mammoth. At the end of the Pleniglacial, the fauna adapted to the cold-zone steppe-tundra dropped considerably within the assemblages, in favor of ubiquitous species favoring temperate environments, reflecting the global warming at the transition to the Holocene (Fig. 7. 21).

7.5 CONCLUSIONS

The woolly mammoth was clearly an important species exploited by Upper Pleistocene human populations, ranking highly together with reindeer, horse and bison, along with other species of ungulates and carnivores, lagomorphs and rodents. Reindeer and horse were exploited more in the extracarpathic area and mammoth was more exploited in the east European Plain. The particular features of the mammoth behavior and biology probably had major influences on human adaptive strategies. During the Upper Pleistocene, Neanderthals and anatomically modern humans often hunted mammoths and also gathered dry mammoth bones from natural deaths, strongly suggesting detailed planning resource acquisition and preservation. Bones were used as fuel and building material, and ivory was a preferred material for humans. Mammoth was exploited by all the techno-cultural complexes of the time, and the species can be seen as a substantial and perhaps even instrumental component in successful territorial exploitation. The mammoth was a fundamental part of human life-ways in this geographic area.

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A view of the evidence

8. LOWER PALAEOLITHIC SMALL FLAKES AND MEGAFAUNA: THE CONTRIBUTION OF EXPERIMENTAL APPROACH AND USE-WEAR ANALYSIS TO REVEAL THE LINK

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ABSTRACT

The recurrent appearance, in Lower Palaeolithic sites, of lithic industries characterized by the production and use of small flakes alongside butchered elephant remains is the focus of this paper. Recent technological, use-wear and residues analyses, as well as experimental protocols, have shed light on the relevant role lithic items of small dimensions played in the tasks performed by early human groups, especially in animal carcass processing. As small flakes are frequently found in association with processed megafauna remains at Lower Palaeolithic sites, this paper explores the potential of the use-wear analysis approach in recognizing the possible nexus between small flakes and the processing of large animals, which is crucial for the behavioral adaptation of early humans in the Palaeolithic. Here, we present some of the preliminary results of the study of small flakes found at two Middle Pleistocene, Lower Palaeolithic sites; Revadim (Israel) and Fontana Ranuccio (Central Italy). These sites are characterized by rich lithic and faunal assemblages, rich in megafauna remains. The results of use-wear analysis clearly testify that in both sites small flakes were used especially for activities related to the cutting of soft material. The experiments that we carried out with replicas of small flakes strongly suggest a link between the use-wear we observed on the archaeological items and specific movements and actions related to butchering. These considerations support the hypothesis that small flakes might have played a specific role in the processing of carcasses of different prey animals, probably including megafauna.

8.1 INTRODUCTION

In recent years, it has become apparent that African, Levantine and European Lower Palaeolithic sites are no longer characterized solely by the production and use of bifaces or large cutting tools. Alongside the production of bifaces, Lower Palaeolithic lithic assemblages also include small-size items generally defined as small flakes or small

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tools (e.g., Burdukiewicz et al., 2003; Agam et al., 2015; Aureli et al., 2016; Sánchez-Yustos et al., 2016; Santucci et al., 2016; Agam and Barkai, 2018).

The production of small flakes seems to be linked to several independent production trajectories, including: 1. the use of small cores, due to the lack of sources of flint nodules available at the vicinity of the sites, as it is the case at the sites of La Polledrara di Cecanibbio and at La Ficoncella, in Central Italy (Aureli et al., 2016; Santucci et al., 2016; Rocca et al., this volume); or maximization of lithic production, for example at the site of Marathousa 1 in Megalopolis, Greece (Tourloukis et al., 2018); 2. the intentional and systematic production of small flakes for specific purposes, as evidenced by the results of use-wear analysis in various Lower Palaeolithic sites (Aureli et al., 2016; Santucci et al., 2016; Bilbao et al., 2019; Venditti et al., 2019a); 3. the recycling/re-use of flakes as core-on-flakes (Zaidner, 2013; Key and Lycett, 2014). Moreover, it was recently suggested that the presence of an intentional production and use of small flakes in Lower Palaeolithic contexts might serve as another indication of the behavioral adaptability of these early human groups (e.g., Venditti et al., 2019b).

The first evidence of the production of small flakes dates back to the African Oldowan contexts (see de la Torre, 2004; Kuman and Field, 2009). However, in Western Europe, the sites of Barranco León and Fuente Nueva 3—situated in southern Spain and dated around 1.2 Ma—show the presence of lithic assemblages made up of small flakes dating back to the Early Pleistocene as well (Toro Moyano et al., 2011).

The production of small flakes become more consistent during the Middle Pleistocene, as evidenced at the sites of La Noira-Unit III (0.68 Ma; Moncel et al., 2013) and Caune de l'Arago (0.57 Ma; Barsky, 2013) in France, and Notarchirico in Italy (640 ± 40 ka; Pereira et al., 2015; Santagata, 2016), amongst other sites. Small flake production seems increasingly common starting from 0.5 and 0.4 Ma; it is evident in some other sites, such as the Spanish site of Gran Dolina-Atapuerca, Visogliano in Italy and Boxgrove in England. (Cattani et al., 1991; Carbonell et al., 2001; Shout et al., 2014).

Alongside lithic industries including the production of small flakes, many Lower Palaeolithic sites across the Old World are characterized by faunal remains of various animal species, ranging from carnivores to medium and large herbivores, and, most prominently, by elephants (specifically, in the cases described here, *Palaeoloxodon antiquus*) (Santucci et al., 2016; Konidaris et al., 2018; Goren-Inbar et al., 2018; Panagopoulou et al., 2018; Konidaris and Tourloukis, this volume).

Such evidence can be found, for example, at Revadim (Rabinovich et al., 2012), Evron Quarry (Tchernov et al., 1994), Holon (Chazan and Horwitz, 2007), and Gesher Benot Ya'aqov in Israel (Rabinovich and Biton, 2011; Goren Inbar et al., 2018), in Greece at the site of Marathousa 1 (Tourloukis et al., 2018), at the sites of Korolevo level VI and Vértesszölös in Ukraine and Hungary (Rocca et al., 2016), in Italy, in the sites of La Polledrara (Anzidei et al., 2012; Santucci et al., 2016), La Ficoncella (Aureli et al., 2016), Castel di Guido (Saccà, 2012), Fontana Ranuccio (Segre, 2004), Venosa-Notarchirico (Piperno and Tagliacozzo, 2001), Isernia La Pineta (Gallotti and Peretto, 2015), and, finally, in Africa, at the site of Bell's Korongo (Sánchez-Yustos et al., 2016).

The stratigraphic association of small flakes and megafauna attracted the attention of the scientific community suggesting the possible use of small flakes in the processing of the fauna. It is true that, in many of these Lower Palaeolithic sites, proboscideans were not the only animals to have been butchered and consumed by Lower Palaeolithic hominins; however, several examples of single-carcass sites, with a single butchered elephant and an industry based on small flakes are of note (Anzidei et al., 2012; Santucci et. al., 2016).

The hypothesis regarding the probable use of small flakes in animal butchering activities has been increasingly addressed and investigated by several studies, often resorting to a combination of experiments and use-wear and/or residue analysis. To this regard, data on use-wear and residue analyses carried out on small flakes from layer C3 at the late Lower Palaeolithic site of Revadim have recently been published (Solodenko et al., 2015; Zupancich et al., 2018; Venditti et al., 2019c), together with supporting evidence found at the Acheuleo-Yabrudian site of Qesem Cave (Venditti et al., 2019a). These studies have shown the existence of a purposeful and systematic production of small flakes at these sites; these small sharp flakes would be used for the execution of specific stages in the butchering process, mainly in cutting gestures that necessitate accuracy and precision.

As it is becoming clear that small flakes were used in animal carcass processing at Lower Palaeolithic sites, the key point that needs to be investigated here is whether small flakes might have played a role also in the processing of megafauna. At the moment, only at the site of La Polledrara di Cecanibbio (Anzidei et al., 2012; Santucci et al., 2016) the results of use-wear analysis, as well as the spatial association between small flakes and elephant remains, have suggested that small flakes were used to butcher carcasses of elephants trapped in the swamp. Our work is based on the assumption that future studies, for example at the site of Marathousa 1 (Tourloukis et al., 2018), as well as at other relevant Lower Palaeolithic sites might reinforce the assumption that small flakes did play a role in the processing of proboscidean carcasses.

This article presents the results of the use-wear analysis of two samples of small flakes retrieved from two Lower Palaeolithic sites, located in Israel and Italy: respectively, Revadim and Fontana Ranuccio. Both sites are characterized by typical Acheulean/Lower Palaeolithic lithic assemblages, but also by a significant assemblage of small flakes and by the presence of faunal remains of large herbivores, especially elephants. This study is part of a broader research framework, aimed at investigating the function of small flakes in various Lower Palaeolithic sites in the Italian peninsula and the Levant (Israel) via use-wear analysis, residue analysis, and the experimental approach. It is an attempt to shed light on the role that small flakes possibly played in the sequence of actions related to the butchering of carcasses. There are plans to test the possible correlation between the functional inferences obtained from the small flakes and the processing of megafauna through dedicated experiments, to be carried out at a later stage.

8.2 THE EXPLOITATION OF ELEPHANTS IN THE LOWER PALAEOLITHIC

Palaeoloxodon antiquus was always an important resource for humans, and many sites in Europe, Asia, and Africa testify to this observation. *Homo erectus* began to use elephants as a source of food in Africa, around two million years ago; the consumption of proboscidean meat and fat continued until the end of the Pleistocene, when these animals became extinct in Europe, the Levant, and the Americas (Agam and Barkai, 2018). These herbivores were sought after by humans mainly because they were large in size and (Ben-Dor and Barkai, this volume), therefore, they guaranteed a significant yield of fat and meat. In fact, a single elephant provided a large amount of fat and a combination of meat and fat together, thus serving as a very important source of energy for the survival and adaptation of human groups (Piperno and Tagliacozzo, 2001; Boschian and Saccà, 2015; Guil-Guerrero et al., 2018; Ben-Dor and Barkai, this volume). Moreover, elephant bone marrow, a substance especially rich in calories and nutrients, played an important role in human diet and could be retrieved from elephant carcasses after having used the animal's meat and fat (Yravedra et al., 2012; Boschian et al., 2019). In this respect, how humans actually used the resources available in these large animals is the source of extensive debate. Were proboscideans hunted or scavenged? Or, perhaps, both strategies were applied? The large size of these animals could have been an obstacle in hunting. However, the hunting techniques and the hunting skills of early humans is still poorly understood and it could have been potentially underestimated. The possibility that early humans procured large quantities of meat and fat in other ways than scavenging is becoming an increasingly accepted hypothesis, based on available archaeological evidence (e.g., Domínguez-Rodrigo et al., 2017) and on the understanding that the high caloric intake needed for humans to stay alive at that time could not be sustained by scavenging alone (Tanner, this volume). It should be mentioned that these huge animals were also used for their bones, which served as raw material for various types of tools (Piperno and Tagliacozzo, 2001; Anzidei et al., 2012; Domínguez-Rodrigo et al., 2014; Guil-Guerrero et al., 2014; Boschian and Saccà, 2015; Santucci et al., 2016).

The presence of elephant remains in numerous Lower Palaeolithic sites across the Old and New World leads to the assumption that these animals were an important resource for human adaptation, especially because of their unprecedented caloric intake potential, that may have supported and sustained the diet, as well as other needs, of Lower Palaeolithic human groups (Agam and Barkai, 2016).

We can define an elephant's body as an "organic quarry" (Lemorini, 2018) that provides humans with a high amount of energy resources for a long time. As stated before, besides large amounts of meat and fat, an elephant may provide highly fatty and proteinaceous elements through its brain, internal organs, and marrow (Konidaris and Tourloukis, this volume), which can be preserved for a long time and may have possibly allowed efficient, long-term use of these resources by early humans, in line with the recent evidence of marrow consumption found at the Lower Palaeolithic Acheulean site of Castel di Guido (Boschian et al., 2019) and of delayed consumption of fallow deer marrow at the late Lower Palaeolithic Achaeuleo-Yabrudian site of Qesem Cave (Blasco et al., 2019). Access to the elephant carcasses by early humans was made possible by lithic tools. As mega-herbivores contain thick deposits of meat and fat, the contact of stone tools with animal bones is rather rare, and so is butchering evidence manifested as cut marks. The presence and variability of cut-marks on the bones can depend on various factors, such as cutting depth, speed in meat butchering, type of tools used, as well as other factors (Haynes and Klimowicz, 2015). This kind of trace is often found on the animal's ribs, scapula, femur, or on limbs: these parts are relatively rich in meat and fat and/or they are locales enabling easy access to internal organs (tail, anus, stomach), which probably were also favored over other parts (Haynes and Klimowicz, 2015; Reshef and Barkai, 2015). Traces of human activity on the bones of these large mammals were found, for example, in the sites of Áridos 2 (Spain), PRERESA (Yravedra et al., 2010, 2012), Revadim (Rabinovich et al., 2012), and Marathousa 1 (Konidaris et al., 2018).

A peculiarity which repeatedly occurs in several archaeological contexts has to do with the association of butchered elephant remains and lithic industries characterized by small tools (e.g., Agam et al., 2015; Santucci et al., 2016; Agam and Barkai, 2018; Konidaris et al., 2018; Tourloukis et al., 2018); moreover, in some particular cases, use-wear analysis has indicated that small flakes were used in butchering operations (Santucci et al., 2016; Venditti et al., 2019c). It must be clarified that other stone tools besides small flakes were produced and used at many of these sites, and thus is it impossible to discuss small flakes as a separate element of the broader tool kits used by early humans. Therefore, we are not suggesting in any way that small flakes were the only category of stonetools employed in butchering operations. On the contrary, we see small flakes as an integral element of stone tool kits, serving early humans in specific tasks alongside a wide array of other categories of stone tools. Moreover, it is clear to us that association does not mean causation, and thus the frequent presence of small flakes alongside butchered elephants cannot be regarded as direct evidence of the use of these small tools in the processing of mega-herbivores, even in cases when functional indications of the use of small flakes in butchery operations have been proven. One should also take into account the fact that, in many cases, other animals were butchered besides elephants in many of these Lower Palaeolithic sites, and one cannot rule out the possibility that stone tools, including small flakes, were used to process different animal taxa. Elephants might be included among these taxa, but they might not have been the only animal processed using small flakes. These reflections and considerations should be taken into account when trying to work out the possible relation between small flakes and elephant carcass processing. We do hope to offer a contribution to this end, and hope that technological advancements in the future may allow to identify specific animal taxa via the study of residue found on Lower Palaeolithic stone tools, and this might provide us with the required direct link between specific stone-tool technologies and the animal taxa processed using the products of these technologies. In the age of ZooMS technologies for identifying animal taxa via a molecular barcode (e.g., Buckley, 2018; Sinet-Mathiot et al., 2019), we are optimistic about the possibility of future developments that will allow to test our hypothesis using more advanced technologies.

The recurrent presence of small flakes alongside butchered elephant carcasses in Lower Palaeolithic sites brings about the following question: did small flakes play a role in the processing of animals in general and of mega-herbivores in particular? This article is an attempt to provide a general overview of the use-wear found on small flakes at the sites of Revadim (Israel) and Fontana Ranuccio (Central Italy), focusing on the use of these small flakes.

8.3 THE ARCHAEOLOGICAL SITES

8.3.1. REVADIM, ISRAEL

Revadim is a late Acheulean open-air site located in the southern coastal plain of Israel. Four seasons of excavation were conducted, from 1996 to 2004, and four areas, A to D, were excavated (Marder et al., 2011: fig. 1). The geological sequence of Revadim has been dated with palaeomagnetic analysis, indicating a normal polarity and suggesting that the site is younger than 780 kya. The U/Th analysis, which was used to date the carbonate covering flint artifacts, provided dates between 500 and 300 kya; this dating allows to determine a minimum age for the human occupation at the site (Marder et al., 2011). The lithic assemblage of Revadim is composed of bifaces, flake tools, choppers, scrapers, flakes, cores, and recycled tools. Regarding the fauna, the most represented species are *Palaeoloxodon antiquus*, *Bos primigenius* and *Dama* cf. *mesopotamica*, and other animal species including microvertebrates (Rabinovich et al., 2012). *Palaeoloxodon antiquus* is the most represented species in the macrofaunal assemblage of the Revadim site and its remains were found in all archaeological layers. Some of the elephant bones were found in Area B, which is probably where specific activities were carried out (Rabinovich et al., 2012; Solodenko et al., 2015). In this area, two layers named B1 and in B2 have been identified, with the latter characterized by a significant amount of flint items and bones (Marder et al., 2011).

In Layer B2 elephant remains have been found, such as two ribs (in one case with cut marks associated to flint tools), a vertebra, and tooth fragments (Marder et al., 2011; Rabinovich et al., 2012; Solodenko et al., 2015). At least 3 elephant individuals were identified at Area B, while an elephant skull fragment, part of a rib, and fragmented elephant teeth belonging to at least two individuals were uncovered in Area C, Layer 3 (Rabinovich et al., 2012).

Area C has been divided in two sections, C3 West and C3 East. In C3 West, five archaeological layers have been identified, from C1 to C5; layers C2 and C3 are the main occupation horizons of the sequence; they are separated by a sterile level (Marder et al., 2011). Layer C3 has the highest concentration of flint items and bones (Agam et al., 2015; Venditti et al., 2019b).

The presence of cut marks in layer B2, such as those found on the scapula and ribs and their association with lithic industry (Locality 21) leads to the possibility that elephant carcasses, as well as carcasses of other animal taxa, were butchered by hominins using flakes, retouched flakes, scrapers, and bifaces (Solodenko et al., 2015; Zupancich et al., 2018).

It should be noted that, in some cases, elephant bone fragments were used to manufacture bone tools at the site (Rabinovich et al., 2012); therefore, the *Homo*-elephant association at the site reflects both the dietary significance of elephants for human consumption and the use of parts of these large mammals for the production of bone artifacts, which might have played an important role in human-elephant relationships (e.g., Barkai, 2019).

8.3.2. FONTANA RANUCCIO, ITALY

The Fontana Ranuccio site is characterized by a fluvial-lacustrine environment and has been dated to 408 kya (Pereira et al., 2018). The site was discovered during the extraction of layers of clay mixed with amorphous volcanic materials (in Italian "pozzolana"), which exposed an impressive stratigraphic sequence beginning with levels attributed to the Villafranchian, based on the presence of *Anancus arvernensis* in the faunal assemblages as well as *Pisidium* malacofaunas (Segre, 2004).

The stratigraphy of Fontana Ranuccio is made up of volcanic or colluvial deposits. The assemblages of the Lower Palaeolithic period are found in a palaeosol, together with faunal remains such as *Palaeoloxodon antiquus*, *Equus ferus*, *Ursus deningeri*, *Cervus elaphus*, *Bos primigenius* and *Dama clactoniana* (Segre, 2004). The lithic industry of Fontana Ranuccio consists of scrapers, cores, flakes, and small flakes made of flint. It is also characterized by the presence of bifaces made of flint, lava, and bone.

8.4 METHODOLOGY

Use-wear analysis was conducted to a sample of small flakes found at the sites of Revadim and Fontana Ranuccio, using an Optical Light Microscope (OLM). The analyses were carried out at the Laboratory of Technological and Functional Analyses of Prehistoric Artefacts (LTFAPA) of Sapienza University of Rome and at the use-wear laboratory of Tel Aviv University.

For the observation of macro-traces, i.e. use-scars and use-rounding, a low magnification approach (Tringham, 1974; Odell, 1980; Lemorini, 2000) was applied, with a Nikon SMZ-745 microscope (with 10× binocular stereomicroscope eyepieces and 1× objective, magnification ranging between 0.67× and 5×, and a reflected light illumination system). This observation allowed to determine the type of action performed and the hardness (soft, medium-hard, hard) of the material worked with the tools.

The high-magnification approach was applied for the analysis of micro traces (Van Gijn, 1989; Lemorini, 2000), using an Optiphot and Nikon Eclipse microscope (with reflected light illumination and 15× and 10× eyepieces, 10× and 20× lenses and digital ToupCam cameras).

This type of observation allowed us to identify polishes and striations, which have developed on the micro surface, and to understand in detail which type of material has been worked.

Unfortunately, the alteration of the lithic surface of the small flakes from both Revadim and

PARAMETER	**CHARACTERISTIC**
Localisation	Ventral/Dorsal/Ventral+Dorsal/Ventral More/Dorsal More
Distribution	Close regular/Close irregular/Wide regular/Wide irregular/Overlapping/Indeterminable
Termination	Step/Feather/Hinge/Snap/Snap-Half moon shape/Indeterminable
Orientation	Oblique unidirectional/Oblique bidirectional/Transversal/Mixed/Indeterminable
Dimension	Small/Large/Mixed
Edge rounding	Low/Medium/High
Typology of worked material	Hard/Medium/Medium-Soft/Soft

Table 8.1: Parameters selected for the indication of macro-traces (F. Marinelli).

Fontana Ranuccio limited the use-wear observation to only macro-traces.

The parameters used to identify the macro-traces are listed in the following table (Table 8.1).

The interpretation of the use-wear observed on the archaeological tools was carried out by reference to a dedicated collection of experimental replicas of small flakes, which were experimentally used for the butchering of proteinaceous portions of the carcass (fat, liver, spleen).

Thanks to the macroscopic and microscopic analyses, it was possible to observe the alteration of the surface of the small flakes found at Revadim and Fontana Ranuccio, and to suggest possible mechanical and chemical processes which have occurred on the surface of these items.

8.5 RESULTS - THE SITE OF REVADIM

8.5.1. THE ARCHAEOLOGICAL SAMPLE

In addition to the small flakes analyzed in this article, layer C3 of Revadim has revealed another type of small flakes, defined as recycled small flakes. Recent technological studies have defined various recycling trajectories at Revadim, aimed at producing small items out of core-on-flakes /flaked flakes (COF-FFs) consisting of old patinated blanks or blanks originating from other knapping trajectories (Agam et al., 2015; Venditti et al., 2019b).

The recent use-wear and residue analyses of the recycled small flakes of Revadim layer C3 led to exceptional results in determining the use of these categories of tools (Venditti et al., 2019c).

In this article, we have analyzed a sample of small flakes found in layer 3 of Area C (East and West), the layer with the highest concentration of flint items and bones of that area. For the purposes of this study, all regular flakes (not recycled ones) whose size ranges from 16 to 20 mm in length have been considered as "small flakes" (Fig. 8.1).

The lowest dimensional limit was chosen to exclude debris from the sample. From now on, we will refer to the selected items as "small flakes".

All the small flakes are made of flint and the sample includes both unretouched and retouched items. In total, 782 small flakes have been analyzed, i.e. 581 un-retouched small flakes (74%); and 201 retouched small flakes (26%). All the items show a high degree of alteration. In fact, the taphonomic processes have significantly modified the surface of the small flakes, which appears highly translucent. At a macroscopic level, small flakes have a very bright surface, with ferrous encrustations and, sometimes, dark shades. The latter may be due to the presence of oxides which confer to the lithic surface some dark tones, ranging from yellow to brown (Fig. 8.2D).

A recent work by Venditti et al. (2019c) has highlighted the presence of different types of post-depositional alterations on the surface of the recycled small flakes found at level C3 of the site. The macroscopic and microscopic analyses have revealed the presence of a brightness on the entire surface of the items, and in some cases, a modification in the color of the original flint. In fact, the surface is characterized by colors ranging from reddish to brown or from orange to yellow. These changes in color, probably due to mineral oxide and hydroxide, are defined as color patina (for more details, see Venditti et al., 2019c).

Despite the surface alteration, flake fragmentation and edge damage are very rare at Revadim, testifying that mechanical processes must have occurred at a very low rate, allowing the analysis of the macro-traces.

The whole sample was subjected to preliminary macroscopic analysis aimed at identifying the presence (or absence) of use-wear. In spite of the post-depositional factors described above, a total of 212 small flakes offered optimal conditions for use-wear analysis. Each of these flakes is characterized by a single active edge on which use-wear has developed, and by a regular morphology, rectilinear in profile.

This sample mainly consists of unretouched small flakes (79%, that is 167 out of 212 items) and, only to a lesser extent, of retouched small flakes (21%, that is 45 out of 212 items).

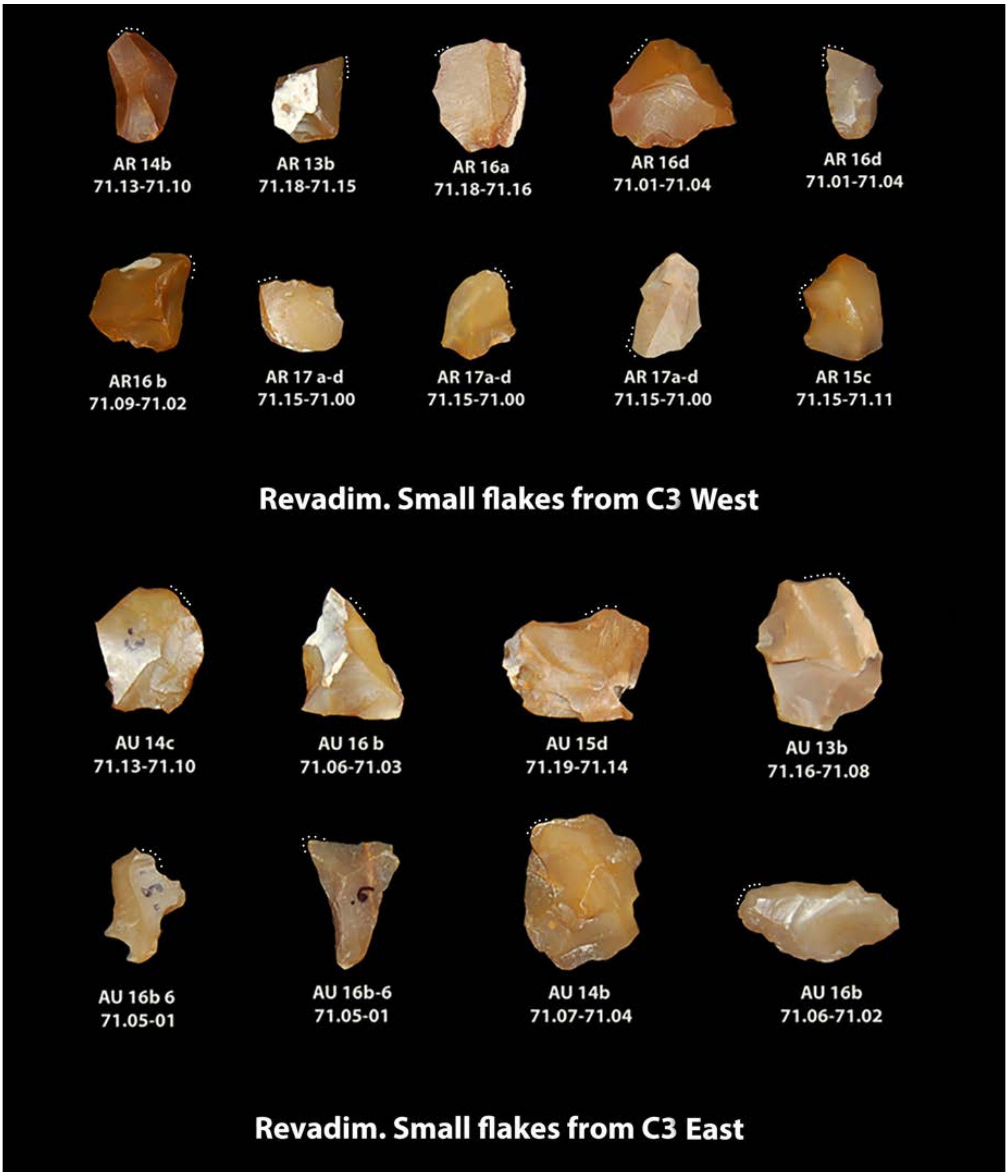

Figure 8.1: Small flakes from the site of Revadim. White dots mark the location of macro-traces (F. Marinelli).

8.5.2. USE-WEAR ANALYSIS OF SMALL FLAKES FROM REVADIM

Use-wear analysis has allowed to reconstruct the activities carried out using the small flakes and determine the degree of hardness of the processed material. The following charts (Fig. 8.3) show the proportion of the activities carried out using each class of small flakes (flakes, retouched flakes).

In some cases, macro-traces were not clearly

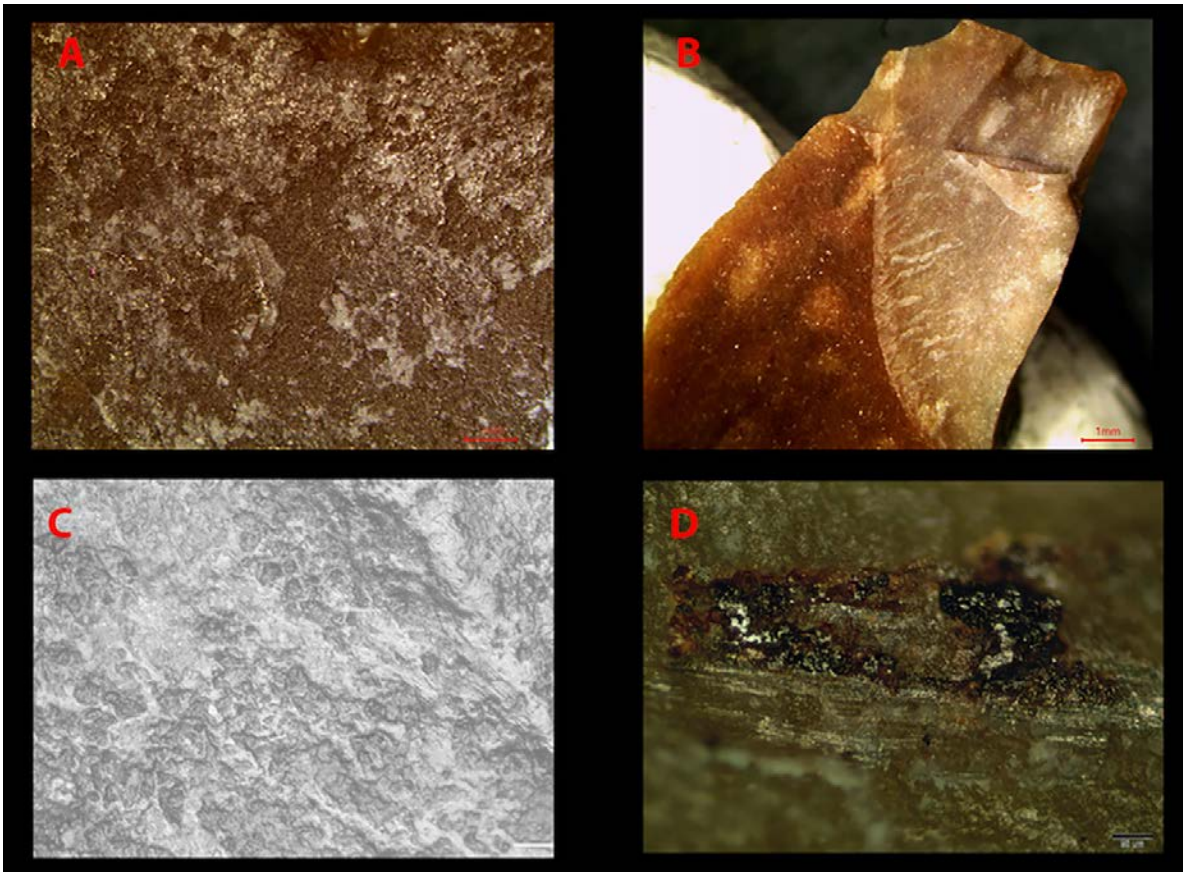

Figure 8.2: Surface alterations on the artifacts from Revadim; **A** and **C**, glossy appearance; **B**, coloured patina; **D**, oxide incrustation (F. Marinelli).

visible, due to the presence of alterations; therefore, it was not possible to identify the type of activity. In this case, the term "general working" was used.

Stereomicroscope analysis showed that in 167 out of 212 small flakes, edge removals are characterized by a close regular distribution and, in most of them (149 out of 167 items), by the feather termination (Kamminga et al., 1979).

Termination is a parameter that provides indications on the hardness of the material being worked (Tringham, 1974; Kamminga et al., 1979). A feather termination suggests that soft materials has been processed, while hinge and or step terminations suggest the contact with harder materials. Thus, the small flakes presented in this article were used specifically to process light materials.

However, as far as the direction of the traces is concerned, in most cases (100 out of 167 flakes) it can be described as oblique unidirectional, the typical direction that develops during cutting activities. As far as scraping is concerned, the direction of the edge removals is transversal to the active edge and tends to develop only on one side of the item (dorsal or ventral), since only one of them was in contact with the material being worked.

Use-wear analysis has indicated that 56% of the flakes (94 out of 167 items) were used in cutting activities, 37% (61 out of 167 items) were used in scraping activities, and 7 % (12 out of 167 items) were used in activities which could not be precisely identified, so they were classified as "general working" (Fig. 8.3A).

Regarding the retouched flakes (45 out of 212 items), edge-removals are similar to those of the unretouched small flakes described above.

The retouched flakes are characterized by a close regular distribution, a feather end-termination (45 out of 45 retouched flakes) and an oblique

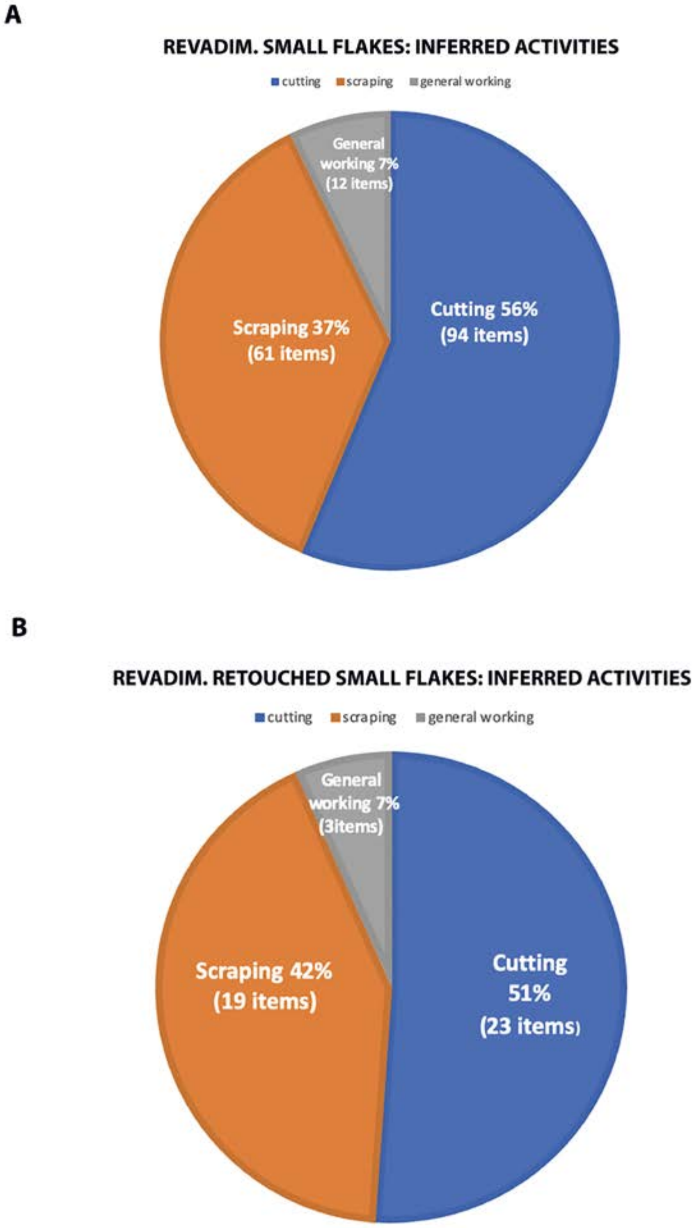

Figure 8.3: Activities inferred from the analysis of use-wear identified on the unretouched and retouched small flakes from Revadim (F. Marinelli).

unidirectional (23 out of 45) or transversal (22 out of 45) direction, interpreted, respectively, as signs of cutting or scraping activity.

Also in this case, the use-wear analysis has allowed to infer that 51% (23 out of 45 items) of the retouched small flakes were used for cutting activities, 42% (19 out of 45 items) for scraping, while 7% (3 out of 45 items) were classified as general working (Fig. 8.3B).

The analysis of the active edges of both categories of flakes indicates that traces can be found only on a small portion of the tool, in particular along the distal end of the active edge that has a naturally pointed morphology (Fig. 8.1).

This leads to the hypothesis that, probably, the parts of the tool in a "pointed" shape were especially selected or favored when carrying out activities which required greater precision (cutting ligaments, tendons, portions of the carcass which were difficult to reach with larger tools).

TYPE	SHAPE	PROFILE	CROSS-SECTION	EDGE-ANGLE AVERAGE
Un-retouched small flakes	Straight: 64%	Straight: 59%	S-S: 55%	26.9
	Concave: 17%	Concave: 19%	S-CV: 13%	
	Convex: 19 %	Convex: 22%	CV-CV: 2%	
			CV-CX: 6%	
			CV-S: 13%	
			CX-CV: 1%	
			CX-CX: 1%	
			CX-S: 3%	
			S-CX: 6%	
Retouched small flakes	Straight: 54%	Straight: 50%	S-S: 56%	27.0
	Concave: 17%	Concave: 21%	S-CV: 11%	
	Convex: 23%	Convex: 29%	C-CX: 7%	
			CV-S: 11%	
			CX-CX: 4%	
			CX-S: 11%	

Table 8.2: Morphologies of the active edge of the studied small flakes from Revadim level C3. S: straight, CV: concave, CX: convex.

As can be seen in Table 8.2, on both the retouched and the un-retouched flakes, most of the active edges have a straight shape and profile.

For activities such as cutting, this morphology is the most functional, since the tools adhere to the material being worked, allowing better performance. Furthermore, in addition to the straight design of the tools, the morphology associated with a convex shape and a convex profile also prevails. A convex morphology might have proven suitable for scraping activities, since the edge can cover a larger surface of the material being processed.

8.6 RESULTS: THE SITE OF FONTANA RANUCCIO

8.6.1. THE ARCHAEOLOGICAL SAMPLE

As regards Fontana Ranuccio in the sample analyzed we have defined as “small flakes” the un-retouched and retouched small flakes whose size ranges from 20 to 30 mm in length. In this sample there are no small flakes below 20 mm, but only debris defined as products of the debitage.

151 specimens have been analyzed: 130 un-retouched small flakes (86% of the sample) consisting of 51 complete small flakes (34%) and 79 fragmented small flakes (52%), and 21 retouched small flakes (14% of the sample) including 12 complete small flakes (8%), and 9 fragmented small flakes (6%) (Fig. 8.4A). Within the sample of retouched complete small flakes, one of them has been recycled (Fig. 8.5A). This item appears to have been heavily affected by water and its coloured patina was partly removed by retouch, aimed at renewing the active edge of the “old” and discarded blank (for more details, see Marinelli et al. 2019: pp. 62–64).

As it is the case with the lithic industry of Revadim, the items of Fontana Ranuccio are characterized by altered surfaces, which appear as very bright (Fig. 8.5B, C, D, E). When observed with a microscope, all the small flakes show a bright, leveled, and cratered micro-surface, defined in the literature as a glossy appearance (Van Gijn, 1989: p. 17; Lemorini 2000: pp. 35–37), which testifies to the occurrence of both mechanical and chemical processes (Fig. 8.5). The small flakes of Fontana Ranuccio show other types of alterations, including oxide incrustations and patinas of var-

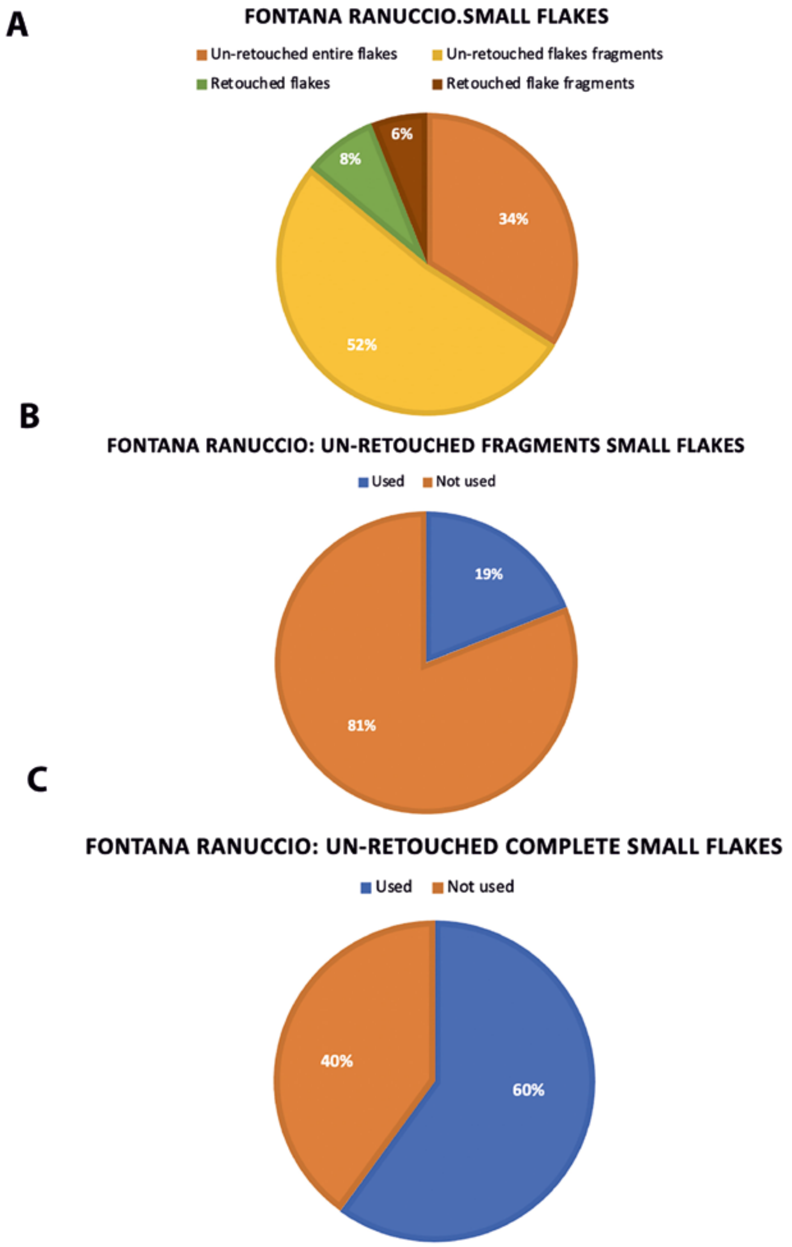

Figure 8.4: Results of the use-wear analysis on the small flakes from Fontana Ranuccio (F. Marinelli).

ious colors, ranging from yellow to brown. Due to post-depositional processes, it was possible to analyze use-wear only on 116 items (Fig. 8.6).

8.6.2. USE-WEAR ANALYSIS OF SMALL FLAKES FROM FONTANA RANUCCIO

The use-wear analysis carried out on the small flakes of Fontana Ranuccio has allowed to infer the type of activity carried out using these tools. As regards the un-retouched flake fragments, use-wear was found only on 12 items (19%) (Fig. 8.4B).

The large amount of fragments which do not show signs of use-wear leads to the hypothesis that these fragments were by-products of the debitage process, or the residual parts of tools fractured during use.

Among the un-retouched complete small flakes,

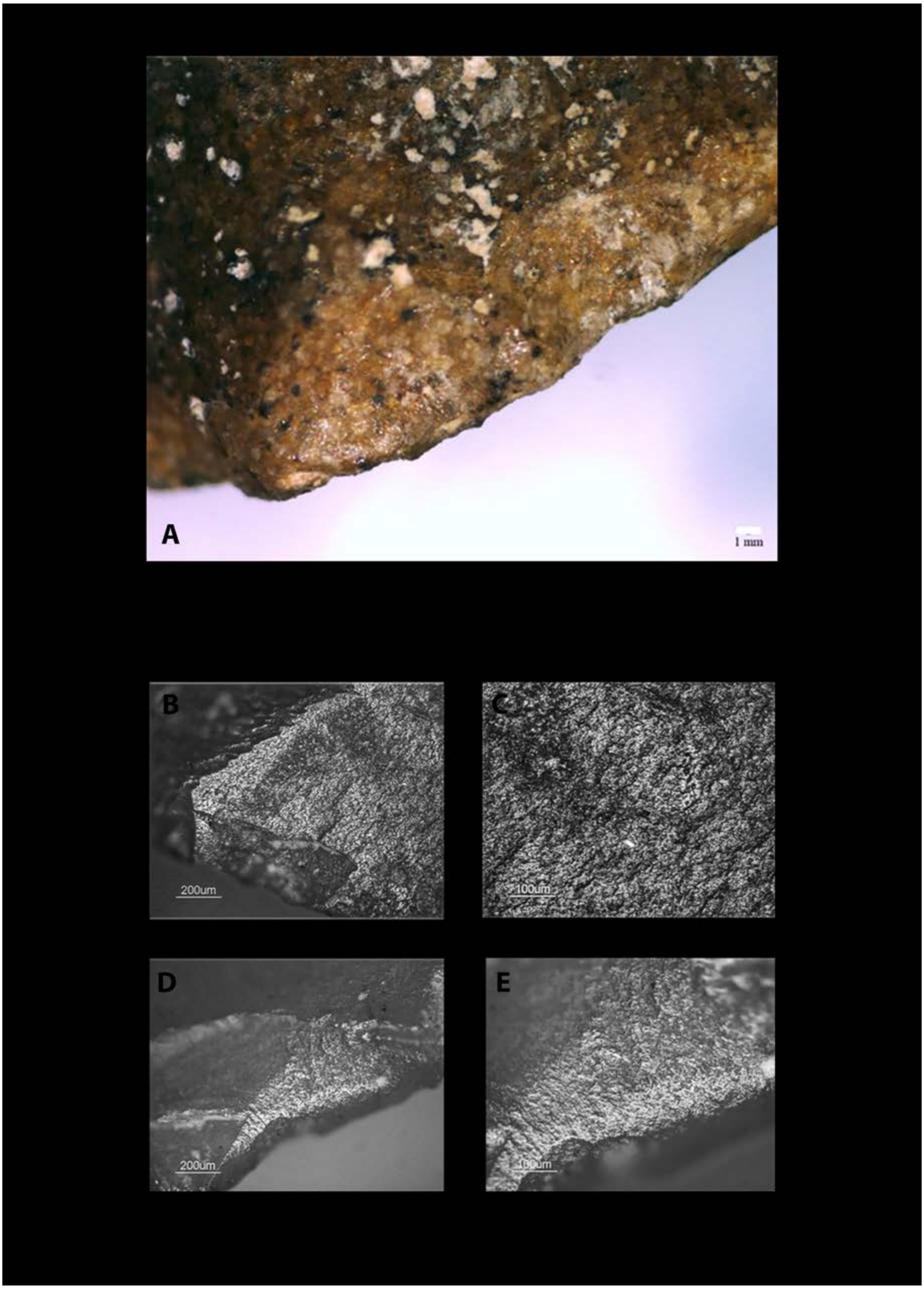

Figure 8.5: Surface alterations on the studied small flakes from of the items of Fontana Ranuccio (F. Marinelli).

Figure 8.6: Small flakes from the site of Fontana Ranuccio. White dots mark the location of macro-traces (F. Marinelli).

on the other hand, 22 items (60%) show signs of use-wear, while 15 items (40%) do not (Fig. 8.4C).

Both fragments and complete small flakes have a close regular distribution, feather-step end-terminations (9 out of 12 small flake fragments; 18 out of 22 un-retouched complete small flakes) and transversal (5 out 12 small flakes fragments; 4 out of 22 un-retouched complete small flakes) or oblique unidirectional (7 out of 12 small flake fragments; 18 out of 22 un-retouched complete small flakes) direction of use.

The identification of these characteristics has allowed to infer the activities carried out using these small flakes. Regarding the un-retouched small flakes, in 18 cases cutting was recognized, while scraping was identified in four cases. As for the fragments, traces attributable to cutting activities were identified in seven cases, and to scraping activities in five cases.

Similar considerations can be made for the retouched small flakes. 14 items (70%, 11 complete and 3 fragmented) have macro-traces. As already observed on the un-retouched small flakes, the retouched flakes have a close regular termination, feather-step end-terminations and transversal or oblique unidirectional directions of use.

In this case too, the analysis has allowed to infer that cutting activities (six cases) and scraping activities (five cases) on lightly resistant and resistant materials were carried out.

The location of the macro-traces on the un-retouched and retouched small flakes is similar. In fact, the macro-traces are often situated at the end of the edge. As it is the case also in Revadim, it seems that the hominins were looking for naturally pointed functional units originated from the intersection between lateral straight edge and the distal end of the small flake.

The preference of tools with pointed functional units was already proposed for the small tools from the site of Ficoncella (Aureli et al., 2016). Three categories of small tools were defined by the techno-morpho-functional approach: spina, mini-rostrum and rectilinear edge.

Mini-rostrum category is represented by items with a pointed area given by the intersection of a concave and a straight edge. The use-wear analysis carried out on this category of tools identified edge-removals on a single mini-rostrum. These use traces develop on the end portion of its straight edge. However, these traces are the remains of edge-removals developed on the previous edge resharpened to create the mini-rostrum (Aureli et al., 2016). Therefore, the mini-rostrum itself has no use-wear; it only keeps the vestiges of the previous use of the small item. Besides mini-rostrum, also the spina category from Ficoncella seems not to bear any use-wear.

Thus, even if the pointed areas were intentionally produced, it is not possible, at the moment, to affirm that they were actual active edges.

On the contrary, the Ficoncella rectilinear edge category includes various items with use-wear developed in sharp active edges with a straight delineation.

In this case, the use-wear analysis testifies cutting activity on medium and medium/soft material. Therefore, the use-wear analysis confirms that these small flakes had a high cutting potential and very robust edges particularly appreciated at Ficoncella to process material of different hardness (Aureli et al., 2016).

However, the small flakes of Revadim and Fontana Ranuccio are characterized by the presence, in almost all cases, of sharp-cornered areas due to the intersection of a lateral sharp and straight edge with the distal end of the flake. Therefore, in the case of these two sites, it would seem that small lithic industries presenting such characteristic morphology were used.

As experimentally demonstrated (see below), the sharp-corner allows to penetrate in the fleshy tissues and to have greater control in those butchering steps where bigger precision was required. In addition, a tool with a straight edge guarantees a larger adherence of the entire active edge to the surface of the material to be processed during cutting activity.

8.7 COMPARISON BETWEEN THE SMALL FLAKES OF REVADIM AND FONTANA RANUCCIO

The results of the use-wear analysis of the small flakes of Revadim and Fontana Ranuccio show that in both sites small flakes were used especially for the cutting—and, to a lesser extent, scraping—of materials of soft consistency. Moreover, in both sites, the small flakes show signs of use-wear in limited and well-circumscribed portions of the active edge (Figs. 8.1, 8.6). In fact, the macro-traces are almost always located on distal or proximal corners. Probably, the most pointed or angular areas of these items were the ones most frequently selected for use.

Because in both sites numerous faunal remains belonging to animal species of various sizes were found and because the small items found in these sites were especially used to process lightly resistant materials, it is reasonable to suggest that these tools may have been part of the toolkit used for butchering activities.

A recent work (Venditti et al., 2019c), carried out on small recycled flakes from Revadim, which were found in the same level as the small flakes described here, has proven that these tools were used in butchering activities. In fact, on the basis of the identified residues and the FTIR analyses, the presence of fat, bone, and collagen fibers was confirmed. These results, together with the use-wear analysis and the experiments, have confirmed the role played by these small recycled flakes during butchering, especially in cases where precise gestures were required (Venditti et al., 2019c).

A first series of experiments allowed to verify that, despite their small size, these tools guarantee

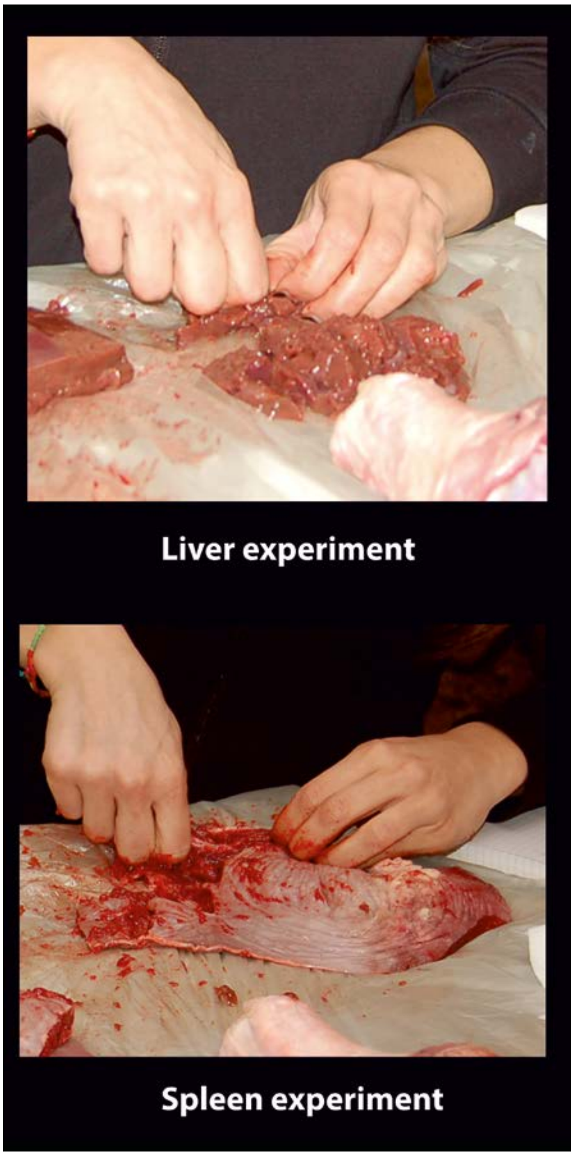

Figure 8.7: Liver and spleen experiments (F. Marinelli).

Figure 8.8: Hide and meat experiments (F. Marinelli).

excellent prehension. In these tools the best grip area is near the butt. This area was probably able to provide greater support for the grip and therefore the tool could be grasped more easily.

As for small flakes and retouched small flakes from Revadim and Fontana Ranuccio, in order to test the possible involvement of these items in butchering activities, we carried out experiments on fresh hide, fleshy tissues (cutting off from bones), and on those parts of the animal's body particularly rich in energy resources, using replicas of small flakes.

8.8 EXPERIMENTS

We carried out dedicated experiments using four replicas of small flakes made with flint from the vicinity of the Revadim site. The experimental replicas were made via direct percussion with a hard hammerstone. We tested the proficiency of these small flakes in cleaning off fat from the inner part of a fresh hide, taking off portions of meat from chest, and cutting the liver and spleen of an adult sheep in slices (Figs. 8.7, 8.8).

Cutting resulted to be the prevailing action;

only during the processing of the fresh hide scraping was also used. Each experiment lasted one hour. The experiments allowed us to verify the effectiveness of the small flakes in slicing muscles and fat organs and collecting fat from the interior side of the hide.

The first experiment was carried out on the liver. The performed action, namely cutting, was carried out with an oblique unidirectional movement (Fig. 8.9A). Despite its very small size, the tool was functional, especially when precision movements—such as the cutting of small portions of tissues—were performed.

The second experiment, the spleen processing, took longer. The cutting activity was carried out with an oblique unidirectional movement (Fig. 8.9B). The greater amount of time required to perform the activity compared to the experiment previously mentioned was due to the fact that the texture of the spleen is more elastic than the liver and, therefore, cutting took longer. In spite of that, the small flake was functional and the prehension was also excellent.

The third experiment consisted of scraping and cutting the fat layer of the inner side of a fresh hide of a sheep. In this case, the tool was involved in two types of activities: first, it was used to remove the adipose layer of the hide with a combined action of cutting or scraping (Figs. 8.8A, 8.9C). Then, we used it to cut the hide and divide it into two halves. The movements were mainly one-way oblique and, only in fewer cases, transversal. The tool was functional for both activities and the prehension was also very good.

The last experiment consisted of removing meat from the ribs of a sheep (Figs. 8.8B, 8.10). This type of activity made it possible to understand even more in depth the degree of efficiency of the small flakes in more precise activities, such as the removal of ribs from the rib cage aimed at improving the collection of residual portions of meat from the bones (Fig. 8.10A). The tool has proven very effective, especially in the areas where ribs connect, where the space between one rib and the other is reduced (Fig. 8.10B). Despite its small size, the tool

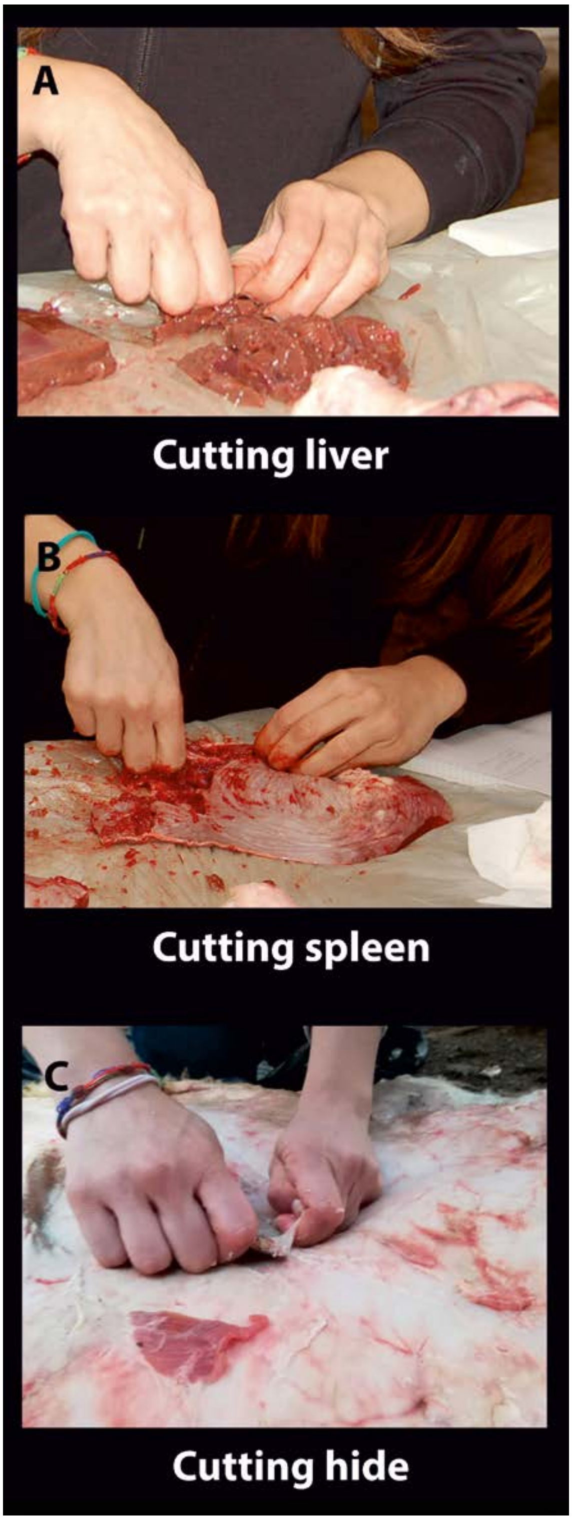

Figure 8.9: Experiments; **A**, cutting liver; **B**, Cutting spleen; **C**, Cutting hide (F. Marinelli).

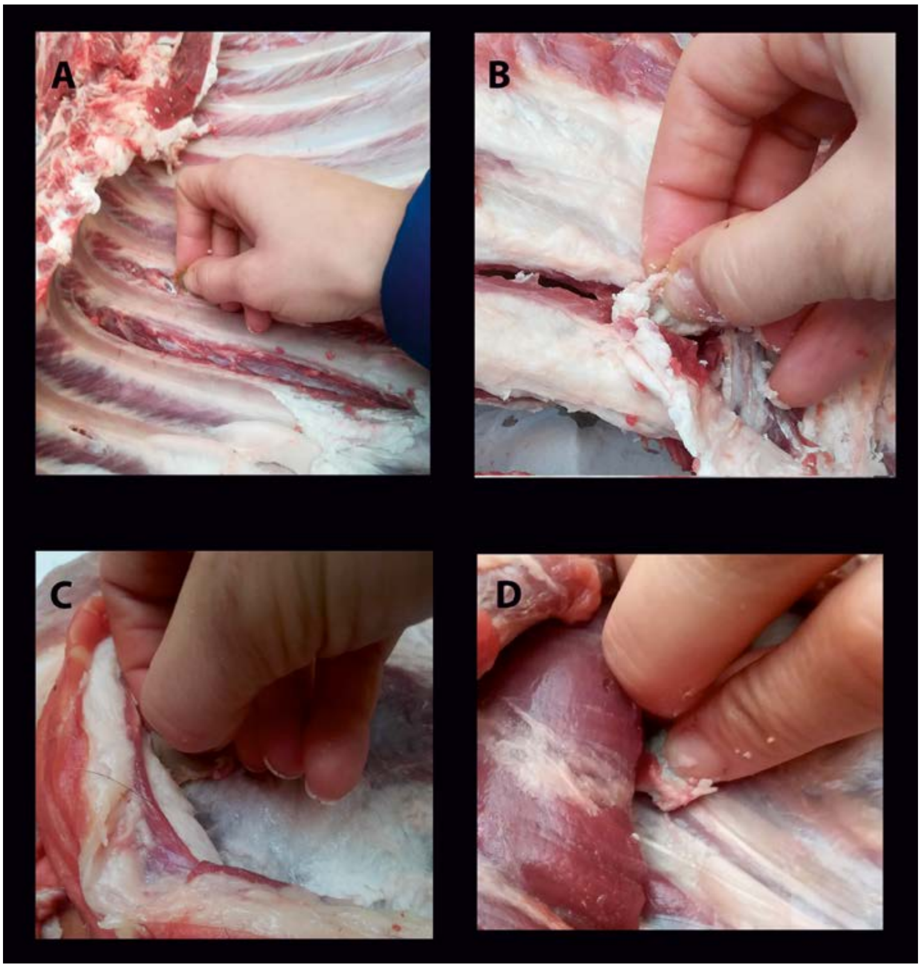

Figure 8.10: Meat experiment; **A**, removal of the ribs from the rib cage; **B**, detail of the cutting activity near the rib; **C**, removal of the meat from rib cage; **D**, detail of small flakes in the cutting activity (F. Marinelli).

was functional even in areas where meat was more abundant (Fig. 8.10C, D). The movements carried out here were mainly oblique unidirectional.

During this experiment, we noticed that in areas with larger amounts of meat the tool had to penetrate more in depth to reach the rib. So, in all situations that required greater penetration and precision from the tool, a small portion of the small flake was used. In our case, the distal portion of the small flakes was the most frequently selected and effective, since pointed areas reinforce the penetration potential of the tool.

The results of these experiments were fundamental to assess the effectiveness of these small flakes in various types of activities. Small flakes performed very effectively in slicing fat organs and collecting fat from the inner side of fresh hide (subcutis). Their gripping efficiency was very high during all the processing, leading to the hypothesis that these tools, despite their small size, may have allowed to perform these kinds of activities to a very high degree of effectiveness.

8.9 CONCLUSIONS

The study of use-wear found on the small flakes of Revadim and Fontana Ranuccio led to interesting considerations regarding their use. Although the items were altered, it was nevertheless possible to carry out the analysis of the macro-traces and, therefore, to interpret archaeological data. The small flakes from both sites were subjected to macroscopic and microscopic inspections in order to document the degree of preservation of their surface. These observations allowed to identify that a glossy appearance affects these lithic industries, probably connected to a combination of mechanical (abrasive) and chemical phenomena.

Where possible, use-wear analysis has allowed to detect macro-traces of activities such as cutting, for the most part, and scraping, in fewer cases. The processed materials are quite homogeneous and, for the most part, consisting of soft materials at Revadim and soft/soft-medium materials at Fontana Ranuccio, suggesting that, in the latter, materials with a harder consistency were worked as well.

All the observations made on the archaeological small flakes were matched with the results of the experimental protocols.

This first phase of experiments confirmed the efficiency of the small flakes in cutting and scraping of soft highly proteinaceous animal tissue, suggesting that the use-wear found on the archaeological items could be related to specific sequences of exploitation of the body parts of carcasses.

The comparison of the experimental and the archaeological data has highlighted that small flakes were used in activities where their pointed morphology—at the end of their active edge—and sharpness allowed to easily penetrate and cut soft animal tissues, even the most fibrous and tenacious and the fattest and slimiest ones.

As noted in the study of the small flakes of Fontana Ranuccio and Revadim and of other small lithic industries of the late Lower Palaeolithic (Anzidei et al., 2012; Aureli et al., 2016; Santucci et al., 2016; Venditti et al., 2019b, c) hominins were constantly after tools of small size with sharp usable areas. Based on the techno-morpho-functional and use-wear analysis it is possible to hypothesize that the generic category of small flakes is composed of several subgroups characterized by slightly different morphologies which were most probably used in specific tasks. It is probable that small flakes with straight edges were suitable for cutting activities, while those with more pointed areas were chosen for actions that required a precise starting marked on the material worked by the first incision impressed by the pointed or the sharp-corner. Besides the prevalent cutting use, a small number of small flakes were used for scarping activities for which at the site of Fontana Ranuccio a convex morphology of the edge was chosen for this activity.

Therefore, we would like to suggest that in complex activities such as butchering which may consist of different sequences of actions due to the size and the state of preservation of the carcass, the category of small flakes with a straight edge and a sharp-corner at the end, having a high potential of cutting, could be very effective in areas more difficult to be accessed with larger tools.

Despite the very small size of the items (from 16 to 30 mm in length), the experiments highlighted that their prehension was optimal. This griping potential of the small flakes found at Revadim and Fontana Ranuccio is still under study. Therefore, in this article we prefer to not discuss any further this functional aspect, which certainly deserves specific discussion after the dedicated experimental protocols currently in progress (for a general discussion of griping and small tools, see Rots, 2010; Chazan, 2013).

A second phase of experimentation to be carried out in the future will focus on butchering experiments performed on animals of various sizes, aimed at verifying the efficiency of small flakes on different kinds of carcasses.

Furthermore, to confirm the possible direct correlation between small flakes and megafauna, we hope we will be able to organize a butchering session on these large animals.

The data presented in this article are part of a preliminary attempt at investigating the role played by small flakes in the processing of animal carcasses by early humans in the Lower Palaeolithic period. According to these data, small flakes seem to be highly suitable for the processing of soft animal tissue, and they seem very efficient especially for the processing of the fat portion of carcasses. We hope these results, together with future studies and experiments, will help deciphering the intriguing possible nexus between small flakes and megaherbivores.

AUTHOR CONTRIBUTIONS

Conceptualization, F. M.; investigation, F. M.; supervision, C. L. and R. B.; writing–original draft, F. M., C. L. and R. B.; writing–review and editing, F. M., C. L. and R. B.

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9. INVESTIGATING THE SPATIO-TEMPORAL DIMENSION OF PAST HUMAN-ELEPHANT INTERACTIONS: A SPATIAL TAPHONOMIC APPROACH

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ABSTRACT

Human-proboscidean interactions are key nodes of complex ecological, cultural and socio-economic systems. In the last decades, evidence has been provided in support of an early human exploitation of proboscidean carcasses, offering further insights into past human behaviors, diet and subsistence strategies. Nevertheless, the mode of acquisition of the carcasses, the degree of exploitation, its timing relative to carnivore scavenging and to the decomposition of the carcass, its ecological and socio-economical role are hitherto not fully understood and a matter of debate. By summarizing the empirical evidence for human-elephant interactions in Early and Middle Pleistocene open-air sites of western Eurasia, this contribution elaborates on the need for a more rigorous, spatially explicit inferential procedure in modeling past human behaviors. A renewed analytical approach, namely spatial taphonomy, is introduced. In its general term, spatial taphonomy refers to the multiscale investigation of the spatial properties of taphonomic processes. Building upon a long lasting tradition of taphonomic studies, it seeks for a more effective theoretical and methodological framework that accounts for the spatio-temporal dimension inherent to any complex system. By bridging into a spatio-temporal framework the traditional archaeological, geoarchaeological and taphonomic approaches, spatial taphonomy enhances our understanding of the processes forming archaeological and palaeontological assemblages, allowing a finer comprehension of past human behaviors.

9.1 INTRODUCTION

Human-elephant interactions comprise complex and interdependent ecological, cultural and socio-economic aspects. While such a manifold relationship might still be observed in relatively few modern hunter-gatherer societies —e.g., among the BaYaka, the Mbuti and the Baka (respectively

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see Lewis, this volume; Ichikawa, this volume; Yasuoka, this volume)—, the origin of it, at least in the form of human exploitation of proboscidean carcasses, could be dated back to the Early Pleistocene. An elephant butchering event was reported to occur as early as ~1.75 Ma at the Oldovai site of FLK North, level 6, Upper Bed I (Leakey, 1971; Bunn, 1981; Potts, 1988) —although the anthropogenic origin of the accumulation was later questioned on the basis of several taphonomic observations (Binford, 1981a; Domínguez-Rodrigo et al., 2007a). Yet, other indications of proboscidean exploitation come from the Early Pleistocene of Africa and Europe: e.g., HWK EE, Olduvai Bed II (de la Torre et al., 2017), FLK North, Olduvai Lower Bed II (Domínguez-Rodrigo et al., 2007b) and BK4b, Olduvai Upper Bed II, Tanzania (Domínguez-Rodrigo et al., 2014b); Barogali, Djibouti (Berthelet and Chavaillon, 2001); Olorgesailie Member 1, Site 15, Kenya (Potts et al., 1999); Fuente Nueva 3, Spain (Espigares et al., 2013); Barranc de la Boella, Spain (Mosquera et al., 2015). Such evidence significantly increases in quantity and archaeological resolution during the Middle and Late Pleistocene (e.g., Villa, 1983, 1990; Goren-Inbar et al., 1994; Piperno and Tagliacozzo, 2001; Gaudzinski et al., 2005; Villa et al., 2005; Müller and Pasda, 2011; Anzidei et al., 2012; Aureli et al., 2012; Rabinovich et al., 2012; Saccà, 2012; Pawłowska et al., 2014; Konidaris et al., 2018; Tourloukis et al., 2018; Aranguren et al., 2019; Yravedra et al., 2019).

Being the largest terrestrial mammals during the Pleistocene, proboscideans ideally constituted optimal sources and reserves of food (Ben-Dor et al., 2011; Reshef and Barkai, 2015; Agam and Barkai, 2016, 2018) and raw material (Gaudzinski et al., 2005; Boschian and Saccà, 2015; Zutovski and Barkai, 2016) —albeit the nutritional/energy return in megafauna exploitation remains debated and non-dietary utilization of proboscidean carcasses might have had more importance than previously thought (Hawkes et al., 1991; Hawkes, 2000; Speth, 2010; Lupo and Schmitt, 2016; Barkai, 2019). Certainly, in the broader, long-lasting debate about the role of meat consumption in the biological and cultural evolution of hominins (e.g., Leakey, 1971; Isaac, 1978; Binford, 1981b, 1984; Potts, 1982; Binford et al., 1988; Blumenschine, 1988; Speth, 1989, 2010; Domínguez-Rodrigo, 2002; Domínguez-Rodrigo et al., 2007b, 2014a, 2017a; Pante et al., 2012, 2015; Thompson et al., 2019), evidence of elephant exploitation, if confirmed, provides further insights into past human behaviors, diet and subsistence strategies.

In this respect, the discovery in recent years of a number of new sites with indications of anthropogenic exploitation of proboscideans (e.g., Aureli et al., 2012; Panagopoulou et al., 2018) and the reexamination of older ones (e.g., Villa et al., 2005; Boschian and Saccà, 2010; Sánchez-Romero et al., 2016; Santucci et al., 2016; Ceruleo et al., 2019) have definitely provided new data and information, but have little increased our knowledge on the mode (hunting or active/passive scavenging), degree (systematic or occasional) and purpose of human exploitation of elephant carcasses. A key research question (among others debated in the scope of this symposium) is: What would elephant hunting and processing sites look like and what kind of archaeological evidence is to be expected?

Tackling this research question is not always straightforward. The empirical evidence might not meet the expectations. First, the spatial association of proboscidean remains with artifacts does not necessarily imply causation. Spatial association, or the degree to which archaeological material occurs in spatial proximity, is a measurable condition of correlation (not causality) and a cornerstone analytical concept in archaeological science (Hodder and Orton, 1976). Nonetheless, it is inaccurately often used as a key, self-explanatory evidence in modeling past human behaviors, set forth by simple exploratory data analyses that mostly involve subjective visual methods (Bevan et al., 2013). As such, spatial association conveys an intuitive perception of spatial interaction and temporal contiguity. However, the observed spatial patterns are rarely distinct snapshots in time and space of human activities and more likely the result of a spatio-temporal palimpsest of natural and cultural processes (Bailey, 2007). As a consequence of the interaction of the archaeological deposit with the biosphere, the atmosphere and the hydrosphere, syn- and post-depositional processes occur and may interact at different spatio-temporal scales. Accordingly, multi-scale spatio-temporal patterns are generated by a variety of anthropogenic (e.g., site re-occupation, recycling), biological (e.g., trampling, carnivore ravaging, burrowing), geological (e.g., deflation, erosion, swelling and shrinking of clay) and chemical processes (e.g., weathering, oxidation). Each process depends on the outcome of the other processes, and has the potential to rework, obliterate or preserve it (Karkanas and Goldberg, 2019). Moreover, different processes may achieve similar outcomes (equifinality) and a single process may lead to different outcomes (multifinality), introducing further pitfalls in the inferential procedure (Lyman, 1994, 2004). In such a complex open system, multiple entities (processes) interact with each other in non-linear, adaptive ways, so that the outcome patterns cannot be easily inferred.

Hence, capturing the complexity of past human-elephant interactions (and past human behavior in general) is highly dependent on solid multidisciplinary analyses. Among others, taphonomic and spatial analyses are certainly of primary importance. Since the first works on early hominid evolution (Behrensmeyer, 1975; Boaz and Behrensmeyer, 1976; Hill, 1976; Gifford and Behrensmeyer, 1977; Brain, 1981), taphonomy has developed a wider theoretical and methodological framework, to the extent that the ephemeral dichotomy between taphonomy and the study of site formation processes, based on the nature of the object of interest, eventually has dissolved in the last decades towards an integrative and multi-disciplinary investigation of the processes, both natural and cultural, that modify the original properties of organic and inorganic material (Domínguez-Rodrigo et al., 2011; but see Lyman, 2010). Moreover, from different spatial perspectives, the analysis of orientation patterns, as well as refitting patterns, size sorting and vertical distributions as indicators of syn- and post-depositional processes, have largely benefit from improved data collection and sampling strategies, advanced analytical methods and enriched experimental/neo-taphonomic references (e.g., Bertran and Texier, 1995; Lenoble and Bertran, 2004; McPherron, 2005, 2018; Anderson and Burke, 2008; Arriaza et al., 2018; Benito-Calvo and de la Torre, 2011; Bertran et al., 2012; Domínguez-Rodrigo and García-Pérez, 2013; Cobo-Sánchez et al., 2014; Ullah et al., 2015; García-Moreno et al., 2016; Clark, 2017; Vaquero et al., 2017). These analyses have been at different levels widely applied in studies of human-elephant interactions (e.g., Villa, 1990; Alperson-Afil et al., 2009; Boschian and Saccà, 2010; Müller and Pasda, 2011; Sánchez-Romero et al., 2016; Santucci et al., 2016). Nevertheless, the integration of spatially-explicit analytical methods in taphonomic studies is not yet fully developed. Especially the study of the spatial distribution and the multiscale spatial correlation of different taphonomic markers is still under-developed. Moreover, it largely lacks a shared and extensive frame of references.

By summarizing the empirical evidence for human-elephant interactions in Early and Middle Pleistocene open-air sites of western Eurasia, this contribution aims to elaborate on the need for a more rigorous, spatially explicit inferential procedure in modeling past human behaviors. A renewed analytical approach, namely spatial taphonomy, is introduced. In its general term, spatial taphonomy refers to the multiscale investigation of the spatial properties of taphonomic processes. Building upon a long lasting research tradition of taphonomic studies, its goal is to move beyond the self-explanatory, indirect evidence provided by the spatial association of faunal remains and artifacts, and to seek for a more effective theoretical and methodological framework that accounts for the spatio-temporal dimension which is inherent to any complex system. By complementing the traditional archaeological, geoarchaeological and taphonomic approaches, spatial taphonomy en-

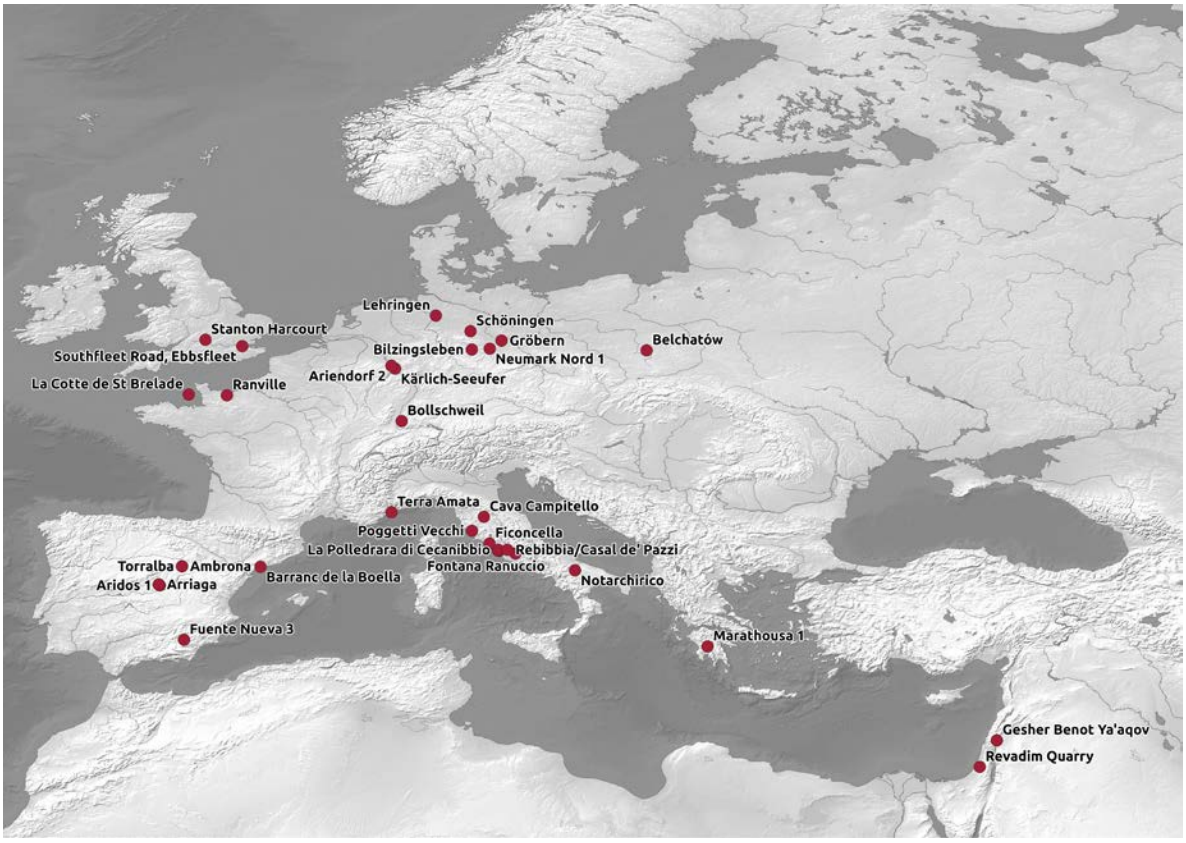

Figure 9.1: Geographical distribution of the sample of Early and Middle Pleistocene open-air sites in western Eurasia with direct or indirect evidence of human-elephant interactions (made using Natural Earth public domain data – naturalearthdata.com).

hances our understanding of the processes forming archaeological and palaeontological assemblages, allowing a finer comprehension of the mode and degree of human involvement in the acquisition and processing of elephant carcasses.

9.2 HUMAN-ELEPHANT INTERACTIONS

9.2.1. DIRECT AND INDIRECT EVIDENCE

The following synthesis is not intended to question current interpretations, but rather to stimulate the discussion on the need for compelling taphonomic and spatial studies for a better understanding of human-elephant interactions. The frequency of direct and indirect evidence, and the composition of the faunal assemblages are discussed for a sample of 35 Early and Middle Pleistocene open-air sites in western Eurasia with a single or multiple elephant carcasses, or with important proboscidean remains in their diverse faunal assemblages (Fig. 9.1).

In these sites, human-elephant interactions are reported on the basis of direct (i.e., cut-marks, proboscidean bone tools or breakages for brain/marrow extraction, tools embedded in proboscidean bones) and/or indirect evidence (i.e., spatial association with artifacts and/or human fossils, tool use-wear and residues patterns, refitting patterns). Like in legal terms, a direct evidence is defined as an evidence that directly proves a fact, without an intervening inference. On the other hand, an indirect evidence, or circumstantial evidence, consists of a fact or set of facts which, if proven true, will support the formulation of an inference. Therefore, in the absence of verified direct evidence, the assessment of human-elephant interactions primarily relies on the accuracy of the indirect evidence and the validity of the inferential procedures.

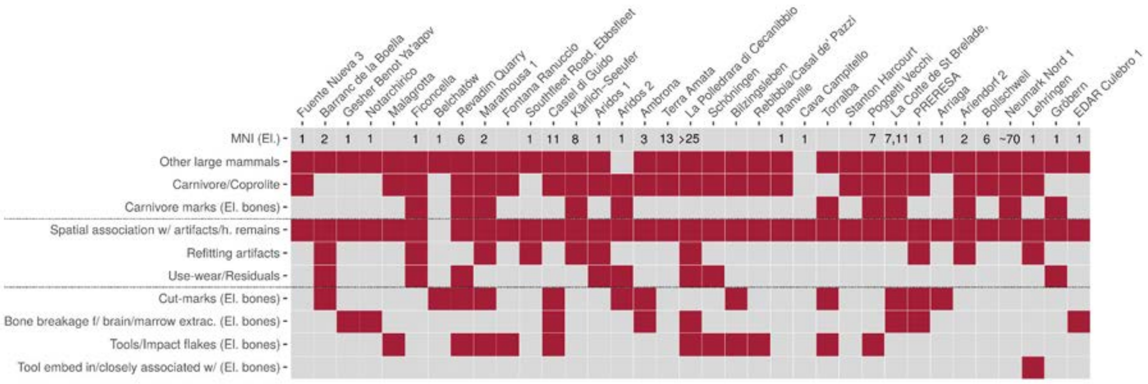

Figure 9.2: Geographical distribution of the sample of Early and Middle Pleistocene open-air sites in western Eurasia with direct or indirect evidence of human-elephant interactions (made using Natural Earth public domain data – naturalearthdata.com).

Yet, despite the primary importance of direct evidence in proving human-elephant interactions, it only offers a relative contribution to the narrative. The place and intensity of cut-marks are considered to be good indicators of the relative timing and aiming of the human access to the carcass (Blumenschine, 1988, 1995). However, cut-mark frequency is observed to be rather low in extant proboscideans due to the thickness of the periosteum and articular cartilage (Haynes, 1991). Moreover, due to a relatively high variability in cut-mark morphology and the lack of a shared, effective methodological framework, their interpretation might be less clear-cut than suggested (Lupo and O'Connell, 2002; Domínguez-Rodrigo et al., 2017b). Breakages for brain or marrow extraction are also relatively rare. The presence of marrow cavities in proboscidean bones seems to be random and not predictable (Villa et al., 2005; Yravedra et al., 2012; Boschian et al., 2019) and it is not clear which breakages were exclusively functional to tool production and which were concurrent to marrow extraction (Zutovski and Barkai, 2016; Boschian et al., 2019). Artifacts made of proboscidean bones are generally rare during the Lower Palaeolithic, although they were quite abundant in very few sites (e.g., Gaudzinski et al., 2005; Rabinovich et al., 2012; Saccà, 2012; Boschian and Saccà, 2015). Regardless of their presence, in the absence of any use-wear/residues evidence, it is still to be assessed whether they had a functional role or not (Zutovski and Barkai, 2016; Barkai, 2019). Tools embedded in proboscidean bones are rather rare and actually absent in the Early and Middle Pleistocene (Wojtal et al., 2019 and references therein). In the absence of other lines of evidence, weapons closely associated with proboscidean bones, such as that at the site of Lehringen (Germany), cannot be considered unequivocal evidence for elephant hunting, likewise any other spatially associated artifacts.

Figure 9.2 shows the presence (in red) and the absence (in gray) of direct and indirect evidence of human-elephant interactions in the sampled sites. In addition, the graph shows the MNI (Minimum Number of Individuals) of proboscideans and the presence/absence in the same assemblage of other medium-to-large-sized herbivores (e.g., hippos, rhinos, Bovidae, Cervidae). The presence of large carnivores is marked positive by the occurrence in the same stratigraphic context of carnivore remains (e.g., big cats, Hyaenidae, Canidae, Ursidae) or carnivore coprolites. Carnivore marks on the elephant bones are also reported. For a complete summary list of the faunal assemblages see Konidaris and Tourloukis (this volume).

Direct evidence of proboscidean exploitation is relatively rare in the sampled Early and Middle Pleistocene record. Specifically, cut-marks are reported in 12 out of 35 sites (34%); bone breakages for brain or marrow extraction in 8 sites (23%); bone tools or impact flakes in 11 sites (31%); not a tool fragment embedded in elephant bones is reported, except for the wooded lance "between the ribs of the elephant" at the site of Lehringen —although the original documentation is rather poor (Weber, 2000). Overall, 63% of the sites reported at least one type of direct evidence; 26% of them reported more than one. Indirect evidence such as tool use-wear and residues (23%) or refitting (29%) patterns are not more frequent than direct evidence. On the other hand, the spatial association of faunal remains with lithic artifacts is certainly the most common evidence in support of human-elephant interactions (in some cases also the only one, in lack of any direct evidence). Interestingly, only few sites rely on a positive combination of multiple direct and indirect evidence. Yet, also in those cases, interpretations are often limited by the complex palimpsest nature of the deposits (e.g., Boschian and Saccà, 2010).

Consequently, the mode of acquisition of proboscidean carcasses and its range of variability in the spectrum of hunting/scavenging strategies, the degree of exploitation (complete, random and partial, selective), its timing relative to carnivore scavenging and to the decomposition of the carcass, its ecological and socio-economical role are hitherto not fully understood and a matter of debate. In the attempt to better comprehend human-elephant interactions, both direct and indirect evidence should be cautiously considered with reference to the depositional context. For instance, an ideal set of evidence in support of butchering activities would include cut-marks, reliable spatial association with tools suitable for butchering, proboscidean protein residues on tools and consistency of use-wear patterns (Haynes and Klimowicz, 2015). For the purpose of this contribution, I will elaborate more on the role of spatial associations in the inferential process. Critical insights might come from the multi-level and multi-scale analysis of spatial patterns.

9.2.2. SPATIO-TEMPORAL PALIMPSESTS

The archaeological record, "at best a static pattern of associations and covariations among things distributed in space" (Binford, 1980: p. 4), nonetheless retains information about the interactions between the past cultural system and its surrounding environment. With reference to human-elephant interactions, we are most likely dealing with human-carnivore-megafauna interactions. Besides the frequency of direct and indirect evidence in the sample of sites, Figure 9.2 shows in addition the presence in the same assemblages of medium-to-large herbivores (including other elephants) and carnivores (also inferred by the presence of coprolites). Carnivore marks on elephant bones are reported in 11 of 35 cases (31%), whereas large carnivore remains or hyena coprolites are reported in 25 sites (71%). Thus, only 8 out of the 35 sampled sites do not include carnivore remains/coprolites or carnivore marks on elephant bones, albeit at least in 2 of them (Barranc de la Boella, Gesher Benot Ya'aqov) the presence of carnivores is attested by carnivore marks on bones other than elephant, and nevertheless occurring in the same stratigraphic layer with the elephant bones and the artifacts. Other medium-to-large herbivores are likely ubiquitous (94%), and sites with an MNI of elephants greater than 1 are 13 (37%). Hence, most of the localities, where human-elephant interactions have been documented, have yielded rich faunal assemblages marked by a significant presence of other medium-to-large herbivores and large carnivores. Both may have played major roles in the formation and modification of the fossil accumulations.

As an example, while the elephants' repeated use of migration trails or paths leading to water sources might have facilitated humans in the practice of particular hunting strategies (Haynes, 2012; Agam and Barkai, 2018), it might have as well triggered intensive trampling especially in those places where accumulations of elephant carcasses usually occur. As a consequence of trampling and kicking (by elephants and other megaherbivores), stratigraphy may be reworked, bones and artifacts may be dispersed and reoriented, edge-damages may occur on stone tools and marks and fractures may be variably produced on bones to the extent of mimicking cut-marks or intentional breaking (Fiorillo, 1984; Andrews and Cook, 1985; Gifford-Gonzalez et al., 1985; Behrensmeyer et al., 1986; Haynes, 1988, 2012; Olsen and Shipman, 1988; Nielsen, 1991; Domínguez-Rodrigo et al., 2009; Gaudzinski-Windheuser et al., 2010; Benito-Calvo et al., 2011; McPherron et al., 2014; Courtenay et al., 2019a, 2020; Pizarro-Monzo and Domínguez-Rodrigo, 2020). Since direct evidence of elephant trampling, such as ichnofossils, are rarely preserved (Palombo et al., 2018; Serangeli et al., 2020), inferences are substantially drawn from the indirect evidence.

Furthermore, the significant presence of carnivores at elephant exploitation sites might have as well considerably increased the system entropy. Carnivore-hominin interactions are traditionally evaluated on the basis of the frequency and distribution of carnivore and anthropogenic modifications on bones (Lupo and O'Connell, 2002; Domínguez-Rodrigo et al., 2007b; Faith et al., 2007; Egeland, 2014), upon their unambiguous definition (James and Thompson, 2015; Domínguez-Rodrigo et al., 2017b) and confident classification. Recent technological advances in the digital acquisition and multivariate analysis of bone modifications (e.g., microscope image acquisition, geometric morphometrics analysis, Bayesian modeling and machine learning algorithms; Bello and Soligo, 2008; Boschin and Crezzini, 2012; González et al., 2015; Harris et al., 2017; Pante et al., 2017; Domínguez-Rodrigo and Baquedano, 2018; Domínguez-Rodrigo, 2019; Courtenay et al., 2019b; Moclán et al., 2019) have overcome much of the biases of more subjective and qualitative approaches and have significantly increased the accuracy in their classification. Nevertheless, the equifinality issue and the spatio-temporal resolution of carnivore-hominin interactions are still major issues affecting the taphonomic interpretation of many sites (e.g., McPherron et al., 2010; Baquedano et al., 2012; Pante et al., 2012, 2015; Domínguez-Rodrigo et al., 2014a; Domínguez-Rodrigo and Alcalá, 2016; Rosell et al., 2019a, b; Saladié and Rodríguez-Hidalgo, 2019).

This issue is equally valid for Early and Middle Pleistocene sites. The mode and degree of human access to and exploitation of animal carcasses might have likely changed with a change in the carnivore guild (see Konidaris and Tourloukis, this volume), and yet the presence of carnivores, similarly attracted by food and water resources, have not overall limited the presence of hominins, and vice versa (e.g., Espigares et al., 2013; Pineda et al., 2017). By creating site structures and assemblage compositions that closely resemble anthropogenic ones, or by modifying at different spatio-temporal scales anthropogenic accumulations, carnivores definitely represent a critical element of uncertainty (Binford, 1981a; Gifford-Gonzalez, 1989; O'Connell et al., 1992; White and Diedrich, 2012; Camarós et al., 2013; Arriaza et al., 2018; Arilla et al., 2020). A formal quantification of such an uncertainty in probabilistic terms marks future direction of analysis (Harris et al., 2017).

Geological processes might as well likely contribute to the building of complex palimpsests. Most of the Early and Middle Pleistocene open-air sites considered here occur in fluvio-lacustrine and palustrine environments. These are known to be attractive locations to animals and to favor archaeological preservation in specific depositional settings. Nevertheless, they are also open, dynamic systems in which diverse syn- and post-depositional geogenic processes take place that might at different spatio-temporal scales rework, erode or preserve the archaeological record (Karkanas and Goldberg, 2019). As an example, White and Diedrich (2012) report that, in addition to primary scavenging by large carnivores and secondary scavenging by smaller carnivores, final disarticulation and scattering of the bones of a modern day elephant carcass were further influenced by the seasonal flooding of the lake shore. Notably, some type of flooding event has been reported in many of the sites discussed here (e.g., Boschian and Saccà, 2010; Marder et al., 2011; Sánchez-Romero et al., 2016; Karkanas et al., 2018).

Indeed, among the variety of natural processes that can contribute to the building of archaeological palimpsests, water flows are certainly the most important and largely studied. Especially in terrestrial alluvial environments, anisotropy (the preferential orientation of fossils or artifacts along the flow direction) is one of the proxies traditionally used to discriminate primary (*in situ*) vs. secondary (reworked) contexts (e.g., Toots, 1965; Isaac, 1967; Voorhies, 1969; Behrensmeyer, 1982, 1988; Nash and Petraglia, 1987; Petraglia and Nash, 1987; Petraglia and Potts, 1994). Consequently, fabric analysis, or the analysis of the orientation of archaeological material as clasts within a sedimentary matrix, has been widely applied in studying human-elephant interactions (e.g., Boschian and Saccà, 2010; Müller and Pasda, 2011; Sánchez-Romero et al., 2016; Peters and Kolfschoten, 2020). However, it is by itself not sufficient to unequivocally discriminate the depositional context and should therefore be integrated with the analysis of other diagnostic features (Lenoble and Bertran, 2004). As an example, anisotropy has been equally documented in autochthonous lag assemblages undergoing minimal re-sedimentation in a modern lake floodplain (Cobo-Sánchez et al., 2014). Moreover, besides water-flow processes, anisotropy has also been observed in association with a wide range of other processes, such as slope processes (Bertran and Texier, 1995), trampling (Benito-Calvo et al., 2011) and carnivore ravaging (Arriaza et al., 2018).

In such a complex, dynamic system, the human exploitation of an elephant carcass might occur at different spatio-temporal scales as well. As an example, contrary to the usually limited extension of archaeological excavations, Hadza kill sites have been observed to be sometimes marked by such a large-scale spatial distribution of associated bone debris and features that largely exceeds that of archaeological sites (O'Connell et al., 1992). Moreover, it is worth considering that, because larger animals such as elephants retain food value for a long time, they can be exploited longer than smaller species (Behrensmeyer, 1987). Recycling of raw material (e.g., bone) and delayed exploitation of elephant meat, fat and marrow might have been more common than traditionally thought (Lemorini, 2018; Boschian et al., 2019).

All these natural and cultural processes, working in such a dilated spatio-temporal framework, variably contribute to the building of complex spatio-temporal palimpsests, with an increase of the system entropy both in terms of amount of disorder (chaos) and loss of information. In this context, spatial association of proboscidean remains with artifacts should undergo scrupulous investigation before being used as evidence of human-elephant interactions.

9.3 SPATIAL TAPHONOMY: THEORETICAL AND METHODOLOGICAL FRAMEWORKS

Unraveling spatio-temporal palimpsests has always been a critical task in archaeology. Despite recent theoretical and methodological advances in palimpsest dissection (e.g., Malinsky-Buller et al., 2011; Vaquero et al., 2012; Barton and Riel-Salvatore, 2014; Davies et al., 2016; Mallol and Hernández, 2016; Martínez-Moreno et al., 2016; Rezek et al., in press), a subtle, diffuse misconception is that it is possible to remove the negative veil of natural post-depositional processes and reveal the original, pristine archaeological occurrence; thus implying the presence of a linear, homogeneous, predictable "background noise" to be erased. On the contrary, cultural and natural processes, working at different scales, frequencies and intensities, are dynamically linked within a spatio-temporal framework. They are so intertwined that it is not possible to remove one without stripping away components of the other.

Borrowed from complex system theory, the concept of "emergence" describes well this property of archaeological palimpsests (Goldstein, 1999; Holland, 2000 and, for a more recent archaeological application, Rezek et al., in press). Emergence is defined as the "the arising of novel and coherent structures, patterns and properties during the process of self-organization in complex systems" (Goldstein, 1999: p. 49). Thus, emergent spatio-temporal structures are patterns that arise in the system as a whole from the interactions in space and time between its components —patterns not otherwise produced by the systemic processes alone. Because emergent patterns are neither predictable, nor reducible to their parts alone, explanation of the system dynamics in term of its elements alone is insufficient. On the other hand, understanding such a complex system is possible by focusing on across-system associations and interactions among its components (Goldstein, 1999). Hence, capturing the complexity of past human-elephant interactions (and past human behavior in general) requires the rejection of the binary, hierarchical opposition between cultural and natural layers; it demands a change of focus from the system components themselves to the whole archaeological record as scale-dependent, emergent interactions between its parts. Variations in the observed patterns can be explained by the system dynamics and the randomness, unpredictability of interactions between its components, which often inherit a spatial dimension. Indeed, the spatio-temporal dimension of emergent patterns has long been universally recognized to be paramount in the investigation of the archaeological record (e.g., Whallon, 1973, 1974; Hodder and Orton, 1976; Clarke, 1977; Butzer, 1982, 2008; Kintigh and Ammerman, 1982; Orton, 1982; Hietala and Larson, 1984; Lyman, 1994; Petraglia and Potts, 1994; Dibble et al., 1997; Wheatley and Gillings, 2002; Conolly and Lake, 2006; Rapp and Hill, 2006; Gillings et al., 2020). With reference to human-elephant interactions, this is especially valid in multi-carcass sites where the archaeological record emerges from complex dynamics of anthropogenic and natural processes (e.g., Boschian and Saccà, 2010; Anzidei et al., 2012).

Therefore, can we attempt to explain such complex systems in terms of the multifaceted interactions between their components, more than as the sum of their parts? Can we estimate uncertainty and account for the observer's bias[1] and the biases derived from missing, time/space-averaged data and spatially uneven sampling strategies? Assuming a spatial dimension of time (Wandsnider, 1992), I argue that the spatial distribution of entities and their attributes is among the most informative aspects of the archaeological variability and that understanding the dynamics of past complex systems requires spatially explicit, multi-scale analytical methods and adequate inferential approaches. Surely, drawing sound inferences highly depends also on accurate data collections, sampling strategies consistent with the scale of the research question, and adequate frames of references with respect to the specific context under study.

Following a long tradition of research in site formation processes —a systemic (processualist) approach that emerged in the '60s from general system theory and strongly advocated the use of quantitative data and hypothetico-deductive models (Binford and Binford, 1968; Clarke, 1968; Flannery, 1968; and Kohler, 2012 for a review), system theory still provides an adequate framework for developing sound methodological approaches to investigate the spatio-temporal dimension of past complex systems such as human-elephant interactions. Many of the lessons of the processualist approach have been nowadays largely assimilated, albeit, a half-century after, many other intuitions have still to find full recognition and application (Shennan, 1989; Lycett and Shennan, 2018). For instance, the call for a multiscale and multilevel analysis of the spatio-temporal dimension of past cultural systems (Clarke, 1968) was possibly ahead of the technology of the time, while it could nowadays generously benefit from the more recent technological advances in GIS, AI and agent based

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[1] On the concept of emergence as a function of the epistemological bias of the observer, Crutchfield (1993: p. 3) noted: "the detected patterns are often assumed implicitly by analysts via the statistics they select to confirm the patterns' existence in experimental data. The obvious consequence is that 'structure' goes unseen due to an observer's biases". An issue related to the natural tendency to seek confirmation, rather then rejection, of our assumptions.

modeling (which in turn are connected to the development of complexity theory).

Nevertheless, the analysis of spatial patterns still lacks a more formal, quantitative framework, being on the contrary mostly based on visual examinations and intuitive interpretations of distribution maps and cross-sectional plots alike (Bevan and Wilson, 2013). Even though such an "eye-balling" technique to read spatial distributions has long been criticized[2], it is still largely used to search for evidence of spatial association and co-variation. Similarly, for many of the sites considered here, a functional association of artifacts with elephant remains has been inferred on the basis of simple visualizations of distribution maps. On the other hand, moving beyond this basic exploratory analysis, more compelling spatial analyses of taphonomic and technological attributes in higher dimensional space might open new research perspectives. Indeed, multiple taphonomic or techno-economic proxies could be eventually spatially defined in order to investigate not only the spatial extension and intensity of taphonomic and behavioral processes, but also the multiscale interactions between them.

In spatial point pattern analysis, points are defined as the location of events generated by a point process (natural or cultural). The intensity of a spatial process, generally evaluated by means of kernel density estimation (Diggle, 1985), informs about its rate of occurrence (uniform or spatially varying across the study area). Although instructive, intensity does not provide sufficient information to reliably infer interactions between processes, which are instead of interest in the analysis of emergent patterns. On the other hand, multiscale inter-point interactions are measured by less common, higher-order statistics, such as the Ripley's K correlation function (Ripley, 1977). In investigating the spatio-temporal dimension of past complex systems, such multiscale and multivariate statistics are extremely useful to determine the type of spatial dependence (i.e., random, positive or negative association) between multiple processes, quantify its strength and spatial range. As an example, with reference to human-elephant interactions, it might be of interest to investigate the three-dimensional spatial dependence between behavioral and taphonomic processes by cross-analyzing techno-functional (e.g., raw material units, artifact types, use-wear/residue traces) and taphonomic proxies (e.g., bone surface modifications, bone breakage patterns, skeletal part profiles, dimensional classes). Furthermore, simulation techniques, such as Monte Carlo methods (Robert and Casella, 2004), might be employed in an hypothesis testing framework in order to build statistical significance and bypass with confidence the equifinality/multifinality inferential pitfalls. Statistical modeling is yet another, less common, but more powerful way to build statistical inference. Indeed, statistical modeling allows one to explicitly fit different explanatory variables to the empirical data. Thus, by building different statistical models and by using model selection techniques, it is possible to choose the best fitting model from among different competing hypotheses (e.g., Eve and Crema, 2014 for an application to archaeological settlement analysis). Moreover, contrary to the frequentist null hypothesis testing, Bayesian inference allows one to estimate model parameters in a probabilistic fashion, taking into account both prior knowledge and empirical data (e.g., Crema et al., 2014; Harris et al., 2017). By using such a probabilistic approach, it is possible to build best predictions starting from incomplete observations (such as the archaeological record), thus acknowledging a certain degree of uncertainty.

Interestingly, in his review of spatial statistics for the study of cultural processes, Orton (1982) beforehand discussed the utility of univariate and multivariate spatial point pattern statistics (e.g., K-function; Ripley, 1977) and the use of Monte Carlo simulations in hypothesis-testing frameworks. Nonetheless, only a relatively small number of scholars have continued to adopt advanced spa-

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[2] "There is a widespread belief that we should go beyond the 'eyeballing' of spatial distributions and develop more objective approaches to the recognition of spatial patterns" (Kintigh and Ammerman, 1982: p. 31).

tial statistics to unravel past human behaviors from scatters of material culture (e.g., Orton, 2004; Bevan and Conolly, 2006, 2009; Crema et al., 2010; Bevan and Wilson, 2013; Crema and Bianchi, 2013; Eve and Crema, 2014; Crema, 2015; Negre et al., 2016, 2017; Reeves et al., 2019). Although these studies acknowledge post-depositional effects, they nevertheless lack explicit consideration of the spatial structure of natural processes. Besides well-developed quantitative methods for the analysis of orientation patterns, advanced spatial statistics are still insufficiently applied to the study of taphonomic processes. Therefore, spatial taphonomy aims to fill this gap. It refers to the multiscale and multilevel investigation of the spatial properties of taphonomic processes. It seeks for a more effective way to investigate past complex system, by bridging the traditional archaeological, geoarchaeological and taphonomic approaches into a spatio-temporal analytical framework.

An early attempt to adopt a specific taphonomic perspective in the analysis of spatial distributions dates back to the early ’80s (Hivernel and Hodder, 1984). More recently, only a relatively small number of studies have answered the need for a more robust spatial analysis of taphonomic processes (e.g., Lenoble et al., 2008; Domínguez-Rodrigo et al., 2014b, c, 2017a; Giusti and Arzarello, 2016; Romagnoli and Vaquero, 2016; Organista et al., 2017; Discamps et al., 2019; Giusti et al., 2019; Mendez-Quintas et al., 2019). Applications to the study of past human-elephant interactions are also relatively few (Sánchez-Romero et al., 2016; Giusti et al., 2018; Mackie et al., 2020; Peters and Kolfschoten, 2020). In these works, a spatially explicit, multi-scale analytical approach allowed to capture the spatial dimension of the processes forming the archaeological record; hypothesis-testing methods were also used to build sound statistical inferences. As an example, Giusti et al. (2018) used a comprehensive set of spatial statistics in order to disentangle the depositional processes at the elephant-butchering site of Marathousa 1 (Greece). Besides orientation patterns and vertical distributions, the authors analyzed spatial trends in either the assemblage intensities and the associations between different classes of remains (e.g., the spatial dependence between two depositional units separated by an erosional contact). All together, these spatial analyses allowed the authors to reliably draw inferences about the autochthonous origin of the assemblage.

Hence, spatial point pattern analysis results particularly useful to investigate the spatio-temporal dimension of taphonomic processes and their multiscale and multilevel interactions with emergent behavioral processes. Moving forward, spatial taphonomy would also benefit from the integration of the spatial dimension in machine learning algorithms (ML) and agent based models (ABM). During the last few years, ML has been successfully applied in taphonomic studies of bone surface modifications, bone breakage patterns and skeletal part profiles (Arriaza and Domínguez-Rodrigo, 2016; Domínguez-Rodrigo and Baquedano, 2018; Byeon et al., 2019; Cifuentes-Alcobendas and Domínguez-Rodrigo, 2019; Courtenay et al., 2019a, b; Domínguez-Rodrigo, 2019; Moclán et al., 2019). These studies employed advanced multivariate statistics and classification methods in order to bypass the equifinality inferential pitfall and to objectively discriminate the human/carnivore agency in fossil accumulation. Likewise, ML allows a through investigation of spatial patterns. For instance, the combination of unsupervised, hybrid and supervised learning has already proved to be effective in the analysis of spatial data and in the identification of discrete fossiliferous levels in palaeontological sites (Martín Perea et al., 2020). Furthermore, by complementing the spatial data with other crucial archaeological, geological and taphonomic attributes, ML would likely allow us to objectively and efficiently reveal the complex interactions that lead to the emergence of archaeological spatio-temporal patterns.

Being understood that the appropriate choice of an analytical technique depends on the context of application, these recent advances in computer science and mathematics are definitely pushing forward our understanding of archaeological palimpsests, promoting a more objective analysis of spatial patterns. Nevertheless, the interpretation of emergent patterns requires valid theory-based models tailored to specific theoretical problems and forms of information. In this regard, ABM provides a convenient framework for developing formal models of complex archaeological systems. ABM, and simulations in general, are primary tools for studying the emergent properties of complex systems, allowing the investigation of changes and interactions in space and time (see Crabtree et al., 2019; Davies et al., 2019; Romanowska et al., 2019 and references therein). For instance, a spatially explicit ABM has been successfully used to model a palimpsest deposit in a fluvial landscape, thus aiding interpretations of the archaeological deposit (Davies et al., 2016).

Nonetheless, drawing sound statistical inferences highly depends as well on references grounded on empirical observations. In order to consolidate the spatial taphonomic approach, it is therefore necessary to build a rich, exhaustive frame of references from actualistic, archaeological or palaeontological cases, where the spatial and taphonomic signatures might be more explicitly recognizable and attributable to particular sets of circumstances. On a side note, the building of effective frames of references would greatly benefit from a broader application of open science practices in archaeology (Marwick et al., 2017). Open access to raw taphonomic data (including spatial coordinates) should be facilitated and promoted if we aim to develop a spatial taphonomic referential framework for both archaeological and palaeontological assemblages (Giusti et al., 2019).

9.4 CONCLUSION

Human-elephant interactions represent key nodes of complex ecological, cultural and socio-economic systems. In the last decades, evidence has been provided in support, to some degree, of the existence of such interactions since the Early Pleistocene and their intensification in the Middle and Late Pleistocene. Nevertheless, the nature of early human-elephant interactions are yet to be fully understood —the mode (hunting or active/passive scavenging), degree (systematic or occasional), purpose of human exploitation of proboscideans and its relation to other systemic agents are hitherto a matter of debate. Models are commonly built by using inductive reasoning from a set of observations that is, for its archaeological nature, very fragmented.

What would elephant hunting and processing sites look like and what kind of archaeological evidence is to be expected? Tackling this kind of research questions would require a high level of generalization that should nevertheless derive from consolidated knowledge about specific processes (Villa et al., 2005). At the site-scale of analysis, there is no single evidence that can lead to a certain solution; but the combination of many, examined within the specific context of each site, might allow probabilistic inferences. This is due to the palimpsest nature of the archaeological record and its extremely high variability generated by the non-linear interactions among different agents (human/carnivore/other megaherbivore) within different dynamic environments. Such interactions inherit an ineluctable spatio-temporal dimension that emerge in spatio-temporal patterns. Thus, on a site-by-site basis, if we tentatively want to shed light on the vast complexity of human-elephant interactions, we should move beyond a reductionist understanding of the whole system in the mere terms of its constituent parts, and instead investigate, within a spatio-temporal analytical framework, the emerging interactions between the different biotic and abiotic components of such a complex system of the past. Spatial taphonomy aims to answer this need by bridging the traditional archaeological, geoarchaeological and taphonomic approaches into a spatio-temporal analytical framework.

In the broad sense, this approach is hardly new —from different perspectives (e.g., orientation and refitting patterns), the spatial dimension of taphonomic processes has long been investigated.

Nevertheless, the study of the spatial distribution and the multiscale spatial correlation of different taphonomic and technological markers is still under-developed. Only a relatively small number of recent studies has successfully investigated the spatial properties of taphonomic processes adopting more compelling spatial statistics and hypothesis-testing methods. Few have applied such methods in studies of human-elephant interactions. In these works, multiscale and multilevel spatial point pattern statistics allowed to draw more reliable inferences about the site formation processes and the human involvement in the exploitation of elephant carcasses. Nevertheless, despite these recent methodological advances, much work has still to be done. Unraveling complex systems such as past human-elephant interactions requires a thorough investigation of the multiscale interactions between taphonomic and behavioral processes. Besides the use of robust spatial statistics, the analysis of such a complex system might further benefit from the critical adoption of other powerful, less common analytical techniques, such as machine learning algorithms and agent based models. Nonetheless, building exhaustive and shared frames of references from theory-based simulations or empirical cases remains a crucial step for the future development of a spatial taphonomic approach to the study of archaeological palimpsests.

On the other hand, the increasing use of an array of advanced quantitative methods and techniques of analysis does not represent any scientific progress if methods and techniques do not follow an epistemological shift. Is the old paradigm "Man the hunter" still projecting its long shadow on the current debate about past human-elephant interactions? After decades of research, much of the discussion is still largely revolving around the hunting vs. scavenging models, while a real shift of perspective towards a more holistic approach is still an ongoing process. By emphasizing the mode of meat acquisition, the risk is to underestimate other important issues, such as the degree of proboscidean exploitation and its relative role with respect to other taxa exploitation, non-animal resources and non-dietary behaviors.

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10. AROUND AN ELEPHANT CARCASS: CIMITERO DI ATELLA AND FICONCELLA IN THE BEHAVIOURAL VARIABILITY DURING THE EARLY MIDDLE PLEISTOCENE IN ITALY

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ABSTRACT

A great number of Lower Palaeolithic sites in Italy yielded lithic industries associated with elephant remains. This recurrent association can give an impression of homogeneity, but in fact the situation is much more complex. This association must rather be seen as a prism to understand the cultural and behavior variability. We investigate this topic through the evidence of two early Middle Pleistocene Italian sites, Cimitero di Atella and Ficoncella, and we try to insert results obtained previously in the framework of the Middle Pleistocene in Italy.

10.1 INTRODUCTION

A great number of Lower Palaeolithic sites in Europe and especially in Italy yielded lithic industries associated with elephant remains (Fig. 10.1). This association has been present since the earliest settlement and all along the Lower Palaeolithic period in various archaeological contexts and in different geographical areas (Konidaris and Tourloukis, this volume).

This rich record stimulated the scientific community to debate the human-elephant relationship issue. One of the most debated issues deals with the role of elephants in the alimentation during human evolution (Agam and Barkai, 2016). From a nutritional point of view, what was the role of meat and fat in the way these human groups fed themselves? From an economic point of view, which were the human strategies to find and exploit these resources? Were the elephants hunted or scavenged? Was the carcass exploited only for food or to provide also bone tools? From a technical point of view, what skills and technical activities were used on these carcasses? Was there a range of tools or only one type of bone tool? Can

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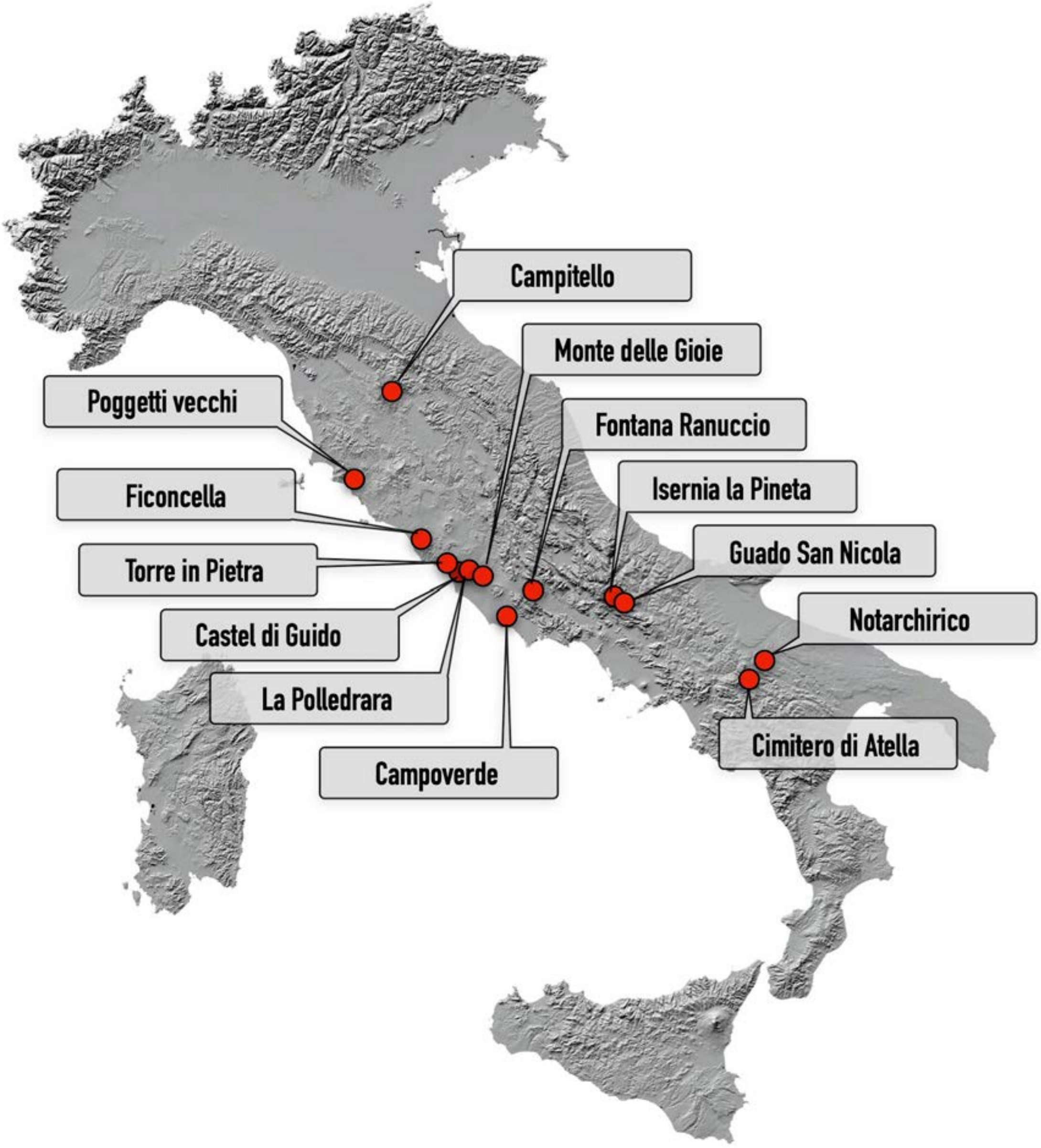

Figure 10.1: Map of the main sites in Italy with elephant remains during the Middle Pleistocene.

we observe changes in the bone tool technical traditions over time and space? And at last, was the role of elephants linked also to the question of the spreading of the genus *Homo* from Africa to Europe (Ben-Dor et al., 2011; Palombo, 2016)? All these issues are of various nature and need to be faced thanks to multidisciplinary studies.

All these in order to emphasize the methodological complexity needed to investigate these archaeological contexts with elephant and lithic industries during the Lower Palaeolithic. This complexity is often increased by the difficulty of interpretation due to the partiality or the lack of preservation, as well as the limited knowledge on the technical and cultural expressions of human groups. The pre-eminence of the environmental studies used as a prism for the human behavior determinism, often makes us lose sight of what the archaeological data has already shown us about well-defined technical traditions in such remote periods.

In this work, we will not present new data on Cimitero di Atella and Ficoncella, but we will rather try to insert the results obtained so far in the framework of the Middle Pleistocene in Italy. The aim is to investigate how these archaeological contexts with elephant and lithic industries enable us to recount important technical and cultural changes over time. Even if this recurrent association between humans and elephants gives a homogeneous pattern, in fact the situation is not as simple as it seems. Indeed, the human and elephant pair should be seen as a prism, which has followed over time the behavior variability and the evolution of technical traditions.

We will investigate this topic through the evidence of two early Middle Pleistocene Italian sites: Cimitero di Atella and Ficoncella. The site of Cimitero di Atella is located in southern Italy. The excavation brought to light an important sequence containing at least two archaeological levels attributed to the lower Acheulean (Borzatti et al., 1997). The lithic implements and faunal remains (*Palaeoloxodon antiquus* and middle-sized mammals) are at the moment dated to ca. 600 ka on the basis of stratigraphic, volcanological and biochronological correlations (Borzatti et al., 1997; Rocca et al., 2016). The site of Ficoncella is located in central Italy, on the left slope of a river valley, in an alluvial sedimentological context, where animal bones and well-preserved lithic remains, dated to the Lower Palaeolithic, were found. The presence of two volcanic layers, as well as other geological evidence, enabled to date the site to ca. 500 ka (Aureli et al., 2012, 2015). Notwithstanding their differences in terms of taphonomic and archaeological context, these two sites allow us to investigate the relationship between humans and elephants during the Lower Palaeolithic in Italy. Therefore, we will compare the site formation processes, the modality of faunal exploitation, the lithic reduction sequence, the tools and the spatial and territorial patterns. Then, we will place our results in the Italian Lower Palaeolithic framework in order to investigate the variability of human-elephant relationships.

10.2 CIMITERO DI ATELLA

10.2.1 PRESENTATION OF THE SITE

The Lower Palaeolithic site of Cimitero di Atella was discovered in the early 1990's and excavated for almost twenty years by Professor Borzatti von Löwenstern and his team (Borzatti et al., 1997). Our new research project is supported by the French school of Rome, and other scientific and local institutions (Rocca et al., 2016, 2018; Rocca and Aureli, 2019).

GENERAL CONTEXT | The Lower Palaeolithic site of Cimitero di Atella is located in southern Italy (Fig. 10.1) in the Basilicata region, at about 10 km south of Monte Vulture. The studied area is located in the frontal part of the south-Apennines orogenic chain. The Atella site is included in a narrow area between the southernmost base slope of Monte Vulture Volcano and the Atella palaeolake.

We observe the presence of lacustrine deposits at the bottom of the stratigraphic succession, related to the Atella palaeolake. The second part of the succession is formed by a debris flow composed of volcanoclastic sediments, and an alluvial sequence is present in the upper part. Several levels, belonging to the Monte Vulture eruptive events, allowed us to re-collocate the sequence within a more precise chronological context (Giannandrea in Rocca et al., 2016). The absolute dating on the volcanic layers identified in this sequence has been directly dated with the $^{40}Ar/^{39}Ar$ method on single grain. The results obtained have shown that all the sequences are comprised between about 650 ka at the base and 585 ka at the top (Pereira, 2017). Further $^{40}Ar/^{39}Ar$ and ESR dating will refine in the future this chronological estimation.

ARCHAEOLOGICAL SEQUENCE | The site of Atella yielded several archaeological units displaying different formation processes (Fig. 10.2). A probable primary position level with quite fresh lithic industry and elephant remains on the top of the lacustrine level, probably linked to a palustrine en-

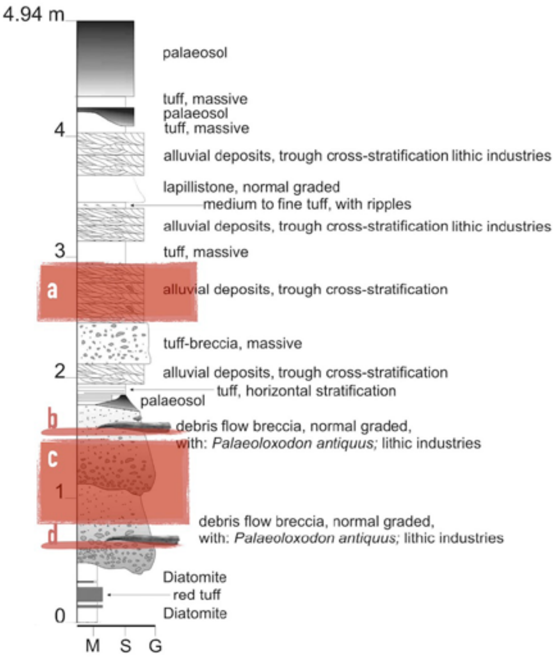

Figure 10.2: Stratigraphic log of Cimitero di Atella, Basilicata, Italy (modified from Rocca et al., 2016). a, sandy deposit of alluvial origin; b, archaeological layer covered by tephra ashes; c, debris flow; d, archaeological level covered by the debris flow.

vironment. A secondary position level with rounded lithic industry and fragmented fauna including a few elephants remains. A primary position level with fresh lithic industry and elephant remains, this level was directly covered by a primary tefra level. And in the alluvial sequence, another horizon with poor lithic industry and a few elephants remains (Rocca et al., 2018; Rocca and Aureli, 2019).

10.2.2 LITHIC INDUSTRY

LITHIC REDUCTION SEQUENCES | The lithic industry of all levels presents on the whole the same characteristics (Fig. 10.3). The assemblage can be divided in three main reduction sequences (Abruzzese et al., 2016; Rocca et al., 2018).

The first reduction is represented by flint small tools and their confection flakes. Not only can small tools be defined by their small size, but also by a common blank structure and a specific confection reduction sequence (Burdukiewicz, 2003; Aureli et al., 2016; Rocca, 2016; Rocca and Serangeli, 2020). The small tools are made both on natural fragments and flakes (Fig 10.3: 4, 5, 6). Whatever is the nature of the selected blanks, they share some important features: small size, considerable thickness, and flat ventral surface used as a striking platform to create the functional part through retouch. The category of retouch flakes coming from the confection of small tools is very well represented. This reduction sequence, small tools and retouch flakes (Fig. 10.3: 2, 3) is mostly represented in the assemblage.

The second reduction sequence is aimed to obtain unretouched flint flakes. The cores belong to the SSDA (surfaces of alternate debitage) production (Forestier, 1993) system or additional types (Boëda, 2013), as the production only affects a sub-volume of the starting block and it is generally limited to a few detachments (Fig. 10.3: 1). The obtained flakes are of medium size, often with one cutting-edge and a lateral back.

At last, we introduce the large tools or large cutting tools in siliceous limestone. Because the shaping of these tools affects almost exclusively only one of their surfaces (Fig. 10.3: 7), we state that the tools previously considered as handaxes are not true bifaces. The blanks used for the confection of these tools are mainly large flat/convex flakes in limestone. They represent a few pieces and no shaping flakes were found, maybe for taphonomic reasons.

LITHIC TOOLS | A techno-functional analysis was conducted on the small tools, aimed to identify the functional potential of stone tools through the description and the analysis of the structure and the tool and its production processes (Boëda, 2013). This preliminary study led to the identification of two main groups: convergent or spina and rectilinear cutting edges (Fig. 10.3: 4, 5, 6) (Rocca et al., 2016, 2020).

The convergent specimens are characterized by a higher degree of transformation: a central arris is omnipresent on the convergence giving strength to the active unit. The prehensile function is per-

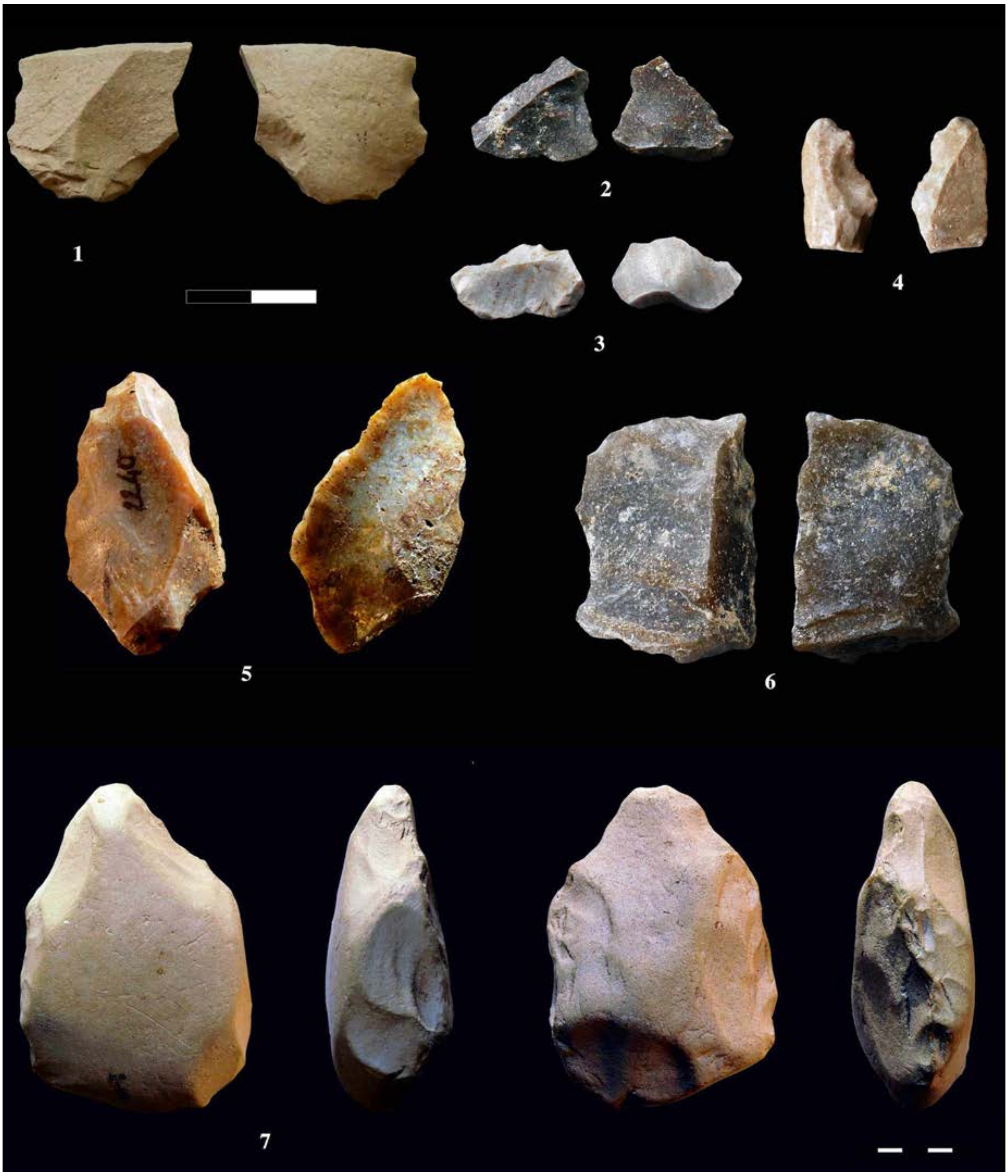

Figure 10.3: Lithic industry of Cimitero di Atella, Basilicata, Italy. **1,** flake; **2–3,** notch flakes; **4–6,** small tools; **7,** large tool.

formed by the thicker portions of the blank, such as the back or the bulb area.

The few and very eroded large tools display open angle cutting-edges, and mainly convergence and rostrum types associated with rectilinear or denticulate edges.

10.2.3 FAUNAL REMAINS

Preliminary observations on the old excavation material have stated that the fauna is highly fragmented and therefore contains few identifiable specimens. Previous excavation, restoration and

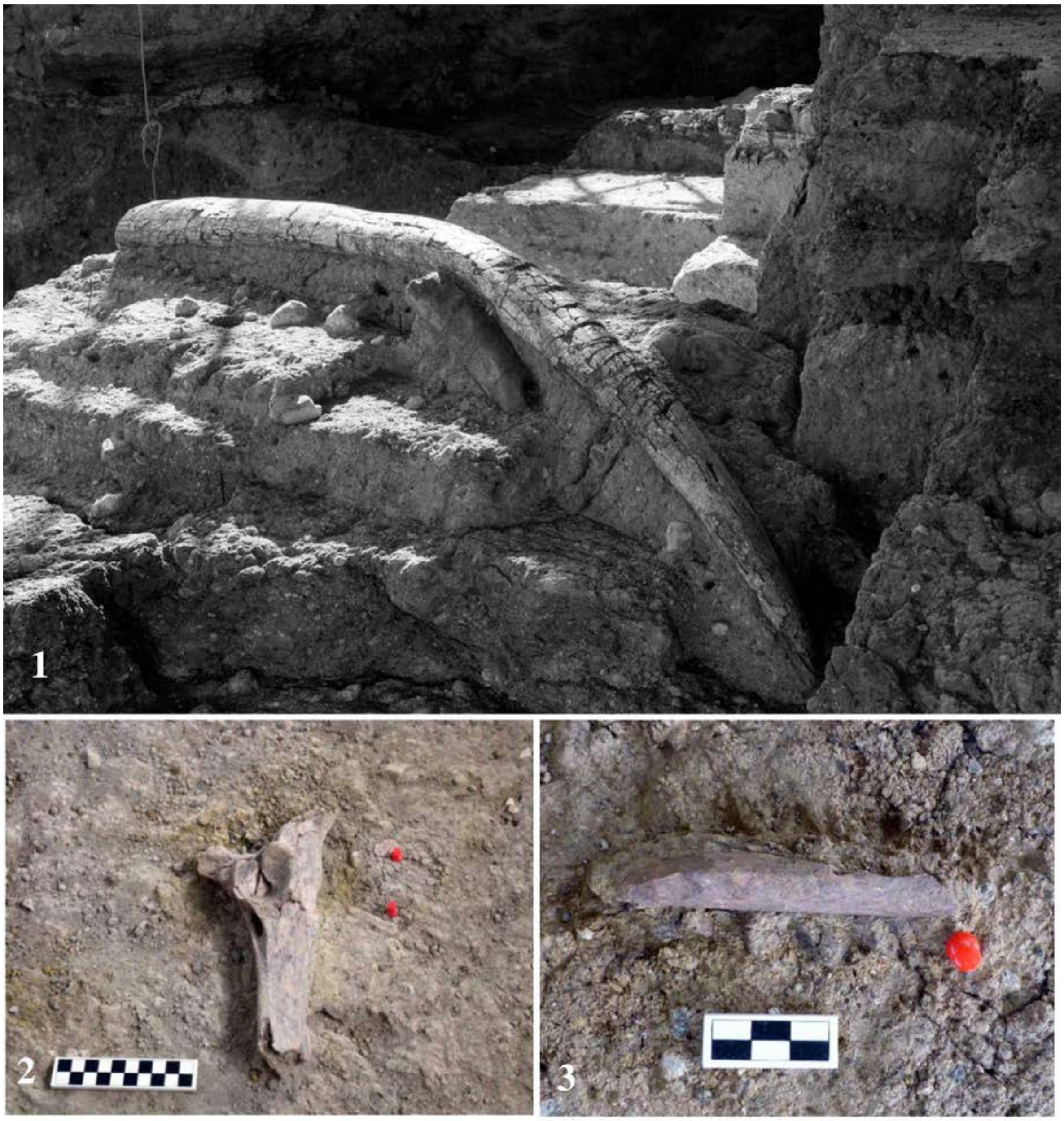

Figure 10.4: Fauna of Cimitero di Atella, Basilicata, Italy. **1,** *Palaeoloxodon* tusk (photo P. Levy); **2,** cervid coxal; **3,** cervid rib.

conditioning procedures have probably affected the conservation of the fauna.

The cervids are the most represented in the assemblage in number of remains, and we can notice the absence of other taxa typical of such assemblages, such as horses. Carnivores and lagomorphs have not been yet identified in the assemblage. The presence of large bovids is confirmed, but the distinction between *Bos* and *Bison* is still in progress (Fig. 10.4: 2, 3). The elephant remains (tusk, molar and long bones) are fragmented and were not found in anatomical connection (Fig. 10.4: 1). No evidence of human modification on the elephant carcass was identified. We hope that the new excavations will increase the degree of diagnostic remains and allow to conduct taphonomic analyses on the fauna.

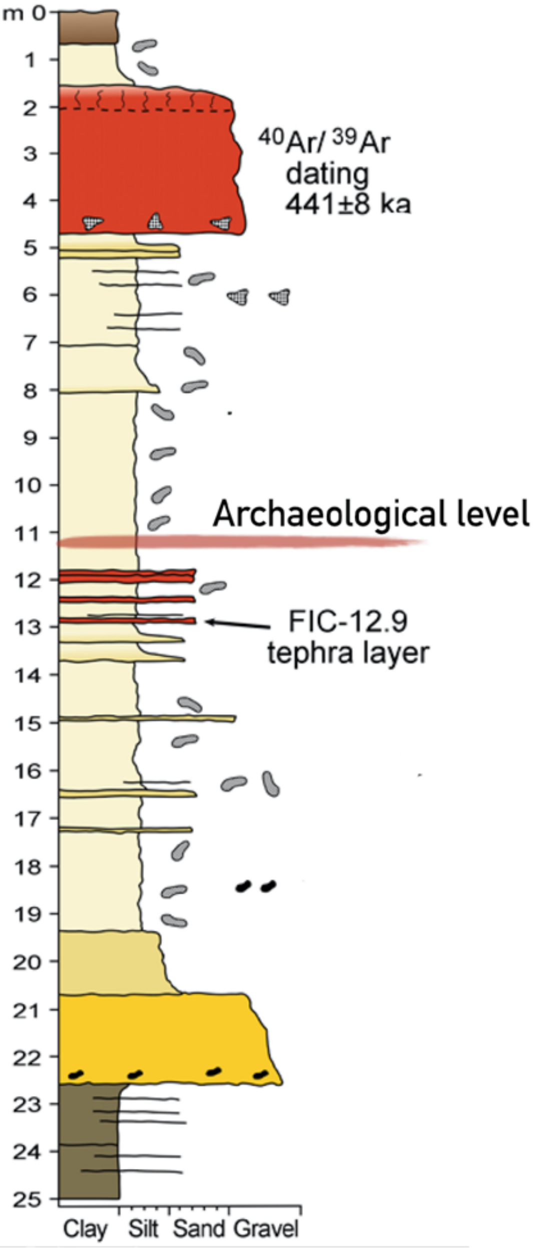

Figure 10.5: Stratigraphic log of Ficoncella, Lazio, Italy (modified from Aureli et al., 2015).

10.3 FICONCELLA

The site of Ficoncella, was discovered by local amateurs, who recovered one elephant scapula in a reworked area and one elephant right tusk. The site was stratigraphically excavated from 2010 to 2015 (Aureli et al., 2015, 2016).

10.3.1 GENERAL CONTEXT

The site is located in central Italy (Fig. 10.1), near the city of Tarquinia on the left slope of the Mignone river valley and consists of an alluvial sedimentological context. Depositional setting is related to the filling of an ancient small valley tributary of the Mignone river.

The presence of two volcanic layers, together with other geological evidence, dated the site between 500 ka and 450 ka. The part of stratigraphic sequence, where animal remains and lithics were deposited, seems to be related to more palustrine conditions, that in a broader floodplain context is generally characterized by the alternation of flood events with sub aerial exposures during dry periods (Fig. 10.5).

The results of the taphonomic and geological analyses, as well as the presence of several refittings, suggest that the formation processes of the Ficoncella site seem to be similar to a snapshot, and that the lithic and faunal remains were buried not long after the elephant's death.

10.3.2 LITHIC INDUSTRY

LITHIC REDUCTION SEQUENCE | The presence of hominin activities is attested by about 500 lithic implements, including very small flakes. No bifaces or other large cutting tools were found in the excavated area. Thanks to technological analyses, we have determined two distinct reduction sequences (Aureli et al., 2016). The first reduction sequence is performed on small flint pebbles, in order to obtain "small-tools" with several cutting-edges (Fig. 10.6: 2, 3). The small flakes coming from this reduction sequence, retouch and notches flakes (Fig. 10.6: 4, 5) are as well used on several work materials. The second one concerns large limestone pebbles exploited to obtain simple unretouched flakes (Fig. 10.6: 1).

LITHIC TOOLS | The unretouched flakes present a rectilinear edge, convergent or not, associated with

Figure 10.6: Lithic industry of Ficoncella, Lazio, Italy. **1,** Flake; **2–3,** small tools; **4,** notch flake; **5,** retouch flake.

an opposite or adjacent back. The presence of macro-traces of use confirms the intended functional potential of the transformative area inferred from the techno-functional analysis (Aureli et al., 2016). For example, some items have edge-removals and edge-rounding interpreted as working of materials of medium hardness through cutting. So, this group is characterized by flakes with a high cutting potential and relatively strong edges, given their use for the processing materials of various hardness (Lemorini in Aureli et al., 2016).

Among the small tools, two main groups were identified. The first group called spina, shows a small pointed part of the tool with a trihedral section, and a central ridge. They are generally associated with an edge of a few millimeters in length, that can be rectilinear, concave or slightly denticulate. We always observe on these pieces one, or more frequently two backs that may play an important role in the grip and the trans-mission of energy. The second category is represented by the mini-rostrum, a small robust bevel with an important angle, of a few millimeters long with a slightly denticulate delineation. We also note the presence of a thick back adjacent to the transformative part that may play an important role in the grip.

The use-wear analysis shows edge-removals on four small tools. Along one of the lateral edges forming the spina and very small edge-removals were observed on the marginal portion of the edge left before the re-sharpening aimed to produce the mini-rostrum (Lemorini in Aureli et al., 2016).

10.3.3 FAUNAL REMAINS

Almost all the faunal remains are fragmented and mostly smaller than 30 mm. Most of the specimens are unidentified due to fragmentation, but a number of them are unidentified skull fragments and flat bones probably linked to the alteration of the elephant skull (Boschin et al., 2018).

The *Palaeoloxodon* skull is incomplete, and comprises the occipital area, the left zygomatic and the maxilla, whilst the right zygomatic bone is not present. The braincase is missing and fragments of

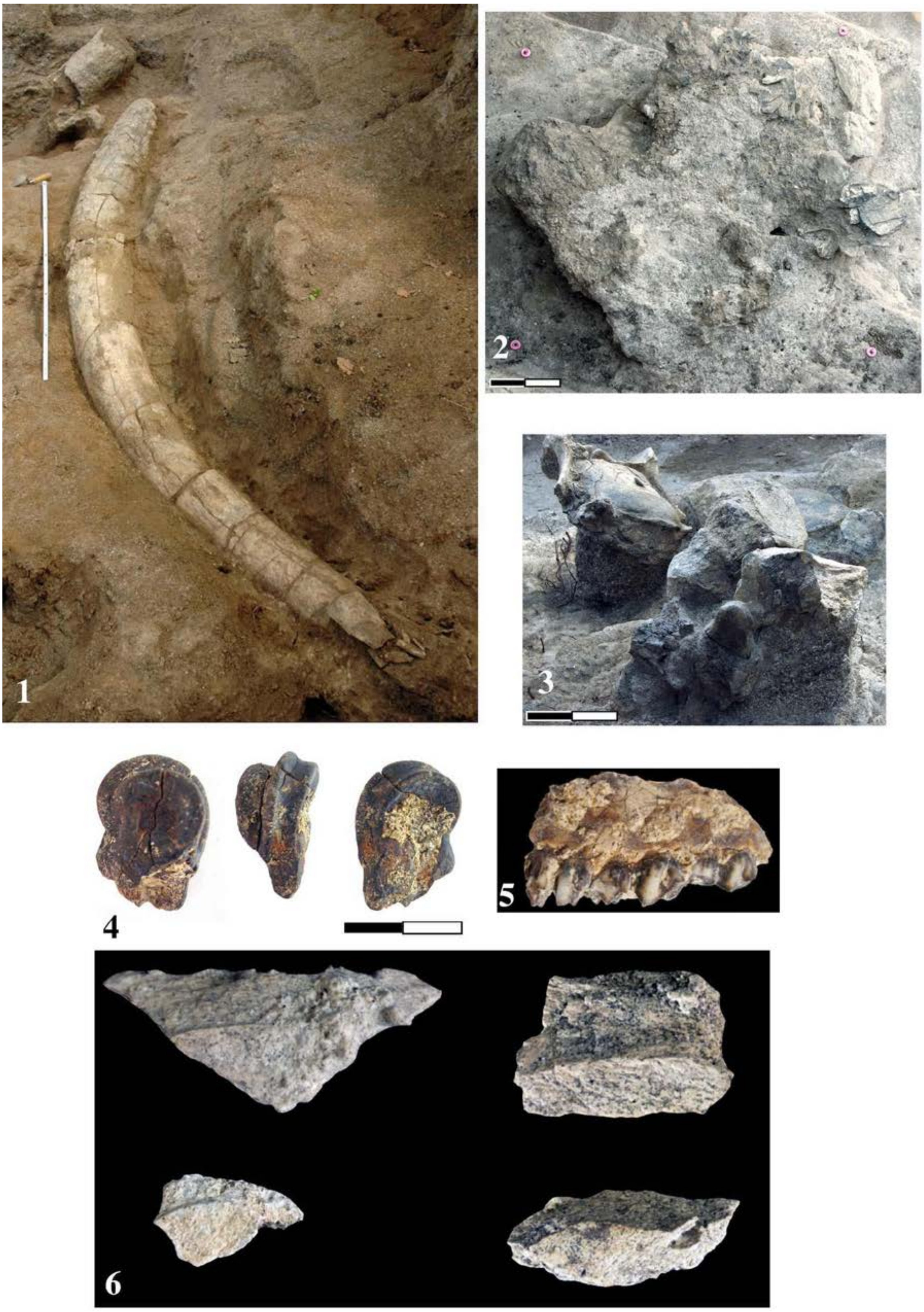

Figure 10.7: Fauna of Ficoncella, Lazio, Italy. **1,** *Palaeoloxodon* tusk; **2,** *Palaeoloxodon* skull; **3,** *Palaeoloxodon* vertebrae; **4,** roe deer distal metapodial; **5,** fallow deer maxilla; **6,** megafauna bone flakes.

Sites	OIS	Large-tool	Hand-axe	Small-tool	Flake	Levallois	Hafting	Bone tool	Digging sticks
Campitello	OIS6?					+++	+++		
Poggetti vecchi	OIS6			++	++		++	+	+++
Campoverde	OIS7			++	++				
Torre in Pietra d	OIS7			++	++	+			
Monte delle Gioie	OIS8			+	+	+			
La Polledrara	OIS9			+++	++			+	
Castel di Guido	OIS9	+	+++	++	+			+	
Torre in Pietra m	OIS10		+++	++	++				
Guado San Nicola	OIS10		+++	+	++				
Fontana Ranuccio	OIS11	+	++	+++	++			+	
Ficoncella	OIS13			+++	++			+?	
Isernia la Pineta	OIS15	+		+++	++				
Cimitero di Atella	OIS15	++		+++	+				
Notarchirico	OIS16	++	+?	+++	+				

Table 10.1: Main features of the Middle Pleistocene elephant sites in Italy.

the premaxillary bones were found near the skull (Fig. 10.7: 2). Tusks were found still in the alveoli (Fig. 10.7: 1). Two complete *Palaeoloxodon* cervical vertebrae, together with the axis, two caudal vertebrae and a fragment of the innominate were found near the apex of the left tusk (Fig. 10.7: 3).

Fallow deer and equid remains were found next to the elephant skull along with other cervids as well as small to mediumsized ungulate remains. In particular, one proximal fallow deer metacarpus was found with the plesio-metacarpal bones still in anatomical connection. In the same area, one roe deer distal metapodial (Fig. 10.7: 4), some cervid remains and a hyaenid coprolite were also found.

Archaeozoological analyses indicate that the elephant carcass was scattered and modified by both carnivores and hominins. On the one hand, a coprolite and a skull fragment with crenulated edges were found at the site, whereas on the other hand, impact flakes from megafauna bones may point to direct evidence of elephant carcass exploitation (Fig. 10.7: 6). As for the hominin modification of the elephant carcass, bone flakes may indicate the intentional breakage of skeletal elements for various purposes: marrow extraction? Bone tool production?

It is intriguing to note that fragments of elephant long bones, most probably the blanks where those bone flakes come from, were not found. It may testify a transport of elephant long bones, perhaps as fragments, to other areas of the site or to other sites, or that the bones flakes were produced elsewhere and introduced in this area of the site. This may confirm that the occurrence of other taxa should not be considered to be originated from the reworking of older sediments as previously hypothesized, since traces of intentional bones breakage were observed, and modifications related to transport by water were not detected. Consequently, Ficoncella cannot be considered as a single carcass site. At the moment, due to the small excavated area and the scarcity of data, it is difficult to know whether individuals belonging to other taxa died at site due to natural factors or if their carcasses were brought there by hominins.

10.4 DISCUSSION

We will now try to compare the results obtained with the published data on the other Italian sites between OIS 15 and 6, where elephant remains were found. To be able to examine the archaeological data in their wholeness, we took into account the following parameters: the archaeological context (geological context, chronological attribution and temporality of occupation), faunal data and technical aspect (Table 10.1).

10.4.1 ARCHAEOLOGICAL CONTEXT

The archaeological contexts of these sites appear quite diversified, some sites being the results of secondary position occupation and others of different degrees of primary position occupation. This needs to be taken into account for the comparison and interpretation. This is also the case for the temporality of occupation, that can influence the interpretation of the data and the nature of the activities on the site.

We can observe different situations: a single and very short occupation, as for example at La Polledrara (Anzidei et al., 2012, Santucci et al., 2016; Pereira et al., 2017) or Ficoncella (Aureli et al., 2012, 2015), but also different occupations repeated for a long time as at Isernia la Pineta (Coltorti et al., 2005).

The geological context is less various, as many sites were buried in lacustrine (Borzatti et al., 1997), alluvial (Radmilli and Boschian, 1996; Lefèvre et al., 2010; Aureli et al., 2015) and in a case at Poggetti Vecchi in a hydrothermal condition (Benvenuti et al., 2017), so often in relationship with a water agent. Sediments of volcanic origin are almost always present and give to the Italian record a particular interest regarding the precision of the chronological resolution (Pereira, 2017).

10.4.2 FAUNAL DATA

As for the fauna, we observe that elephants are never the only represented taxon (Mazza et al., 1992, 2006; Borzatti et al., 1997; Piperno and Tagliacozzo, 2001; Boschian and Saccà, 2010; Aureli et al., 2012; Saccà, 2012; Peretto et al., 2016; Rocca et al., 2016, 2018; Santucci et al., 2016; Boschin et al., 2018), even in short time occupation, at the exception of one level of La Polledrara (Anzidei et al., 2012). We need to remind that the dimension of megafauna remains has also contributed to the overrepresentation of this taxon in the site, as it is often at the origin of the site discovery.

Concerning the bone taphonomy: if some elephant bones are often in anatomical connection, some parts of the carcass were in many cases moved by humans and/or carnivores, even in a well preserved primary context, such as Ficoncella (Boschin et al., 2018), some levels of Notarchirico (Piperno and Tagliacozzo, 2001) or La Polledrara (Santucci et al., 2016). The impact fractures on elephant bones are well represented (Peretto et al., 2004, 2016; Saccà, 2012; Santucci et al., 2016) and mainly interpreted for the marrow extraction, unlike the cut marks that are very rarely present on the elephant bones, even when observed on the other taxa, as for example at Castel di Guido (Saccà, 2012; Boschian and Saccà, 2015), Guado san Nicola (Peretto et al., 2016) and Poggetti Vecchi (Aranguren et al., 2019).

The exploitation of elephant bones for tool making is in state of art poorly represented (Anzidei et al., 2012; Boschian and Saccà, 2015; Aranguren et al., 2019). This could be linked to taphonomic reasons and to the difficulty to identify the elephant bones among fractured remains. This can also be explained by interpretative bias. Indeed, the bone flakes are often interpreted as the results of alimentary activities. These remains should be studied more deeply to confirm this hypothesis thanks to technological (Christensen and Goutas, 2018) and techno-functional analysis in comparison with the stone tool kit.

10.4.3 TECHNICAL TENDENCIES

At last, we try to sum up the technical evidence to have an overview of the main tools evolution. The technical traditions associated to the elephant sites are various, in terms of reduction sequence, types and nature of tools.

Concerning the large-tool and handaxes, these tools are poorly represented but very different in the initial phases (Borzatti et al., 1997; Piperno, 1999; Moncel et al., 2019) and began to be more important but not always present during OIS 10–9 (Nicoud, 2011; Peretto et al., 2016; Arnaud et al., 2017; Pereira et al., 2018) and were totally absent during the recent phase. This indicates the absence of link between large tools and elephant carcass exploitation.

The small tools with very varied cutting-edges are present all along the period on almost all sites (Peretto et al., 1994; Aureli et al., 2016; Villa et al., 2016; Arnaud et al., 2017; Rocca et al., 2018) with the exception of Campitello (Mazza et al., 2006). However, we can observe that the blank procurement modality has been changing through time. During the earliest phases the blanks were mostly based on the selection as in the latest site the small tools are made on flakes. We can notice that, some elephant sites yielded only small tools like at La Polledrara (Anzidei et al., 2012; Santucci et al., 2016), while no sites contain only handaxes. The unretouched sharp flakes were also present during all the period (Aureli et al., 2016; Santagata, 2016; Rocca et al., 2018).

The production modalities have evolved from additional systems (as at Ficoncella) to more integrated systems such as Levallois, from OIS 8 at Torre in Pietra and Monte delle Gioie in Lazio (Soriano and Villa, 2017). When this Levallois concept developed, both bifacial and small tools begin to disappear, and in parallel the hafting emerged as it was attested at Campitello (Mazza et al., 2006).

Finally, around elephant carcasses, bone tools are found at some sites. Even if the research on this aspect must continue, we can already observe that bone tools seem to be close to the stone tools: handaxes at Castel di Guido and Fontana Ranuccio (Boschian and Saccà, 2015), or small tools at Fontana Ranuccio and Polledrara (Anzidei et al., 2012; Marinelli et al., 2019). At Poggetti Vecchi, also wooden tools were found, interpreted as diggings sticks, during OIS 6 (Aranguren et al., 2018), providing a small window into the hidden technical complexity of these groups.

The current trend towards specialization can create methodological obstacles. This problem is obvious in the case of bone tools, mainly produced during the Lower Palaeolithic on elephant bone fragments. If the bone handaxes of central Italy were quite easily recognized as human artifacts (Boschian and Saccà, 2015) simple flakes and maybe small tools on the same raw material are more difficult to identify. The study of fauna is still too often exclusively carried out through an archaeozoological and not in technological prospect. The collaboration between experts of lithic and bone technology and archaeozoologists, and the revision of the collection may allow to have a fresh look at the use of elephant bone materials during the Lower Palaeolithic.

10.5 CONCLUSIONS

In short, we can wonder what tendency has emerged from this overview of the relationship between humans and elephants in Italy.

It is obvious that elephants in Italy were very important during the Middle Pleistocene, present almost in all sites where fauna is preserved, even if this presence can in part be explained by the dimensions of their bones that facilitate the site's discovery. First of all, concerning the evolution of lithic tools, we face a much more complex situation regarding the technical evolution. We have observed a great diversity of tools and reduction sequences. However, the same tendencies have been recorded in southwestern Europe in other sites without elephant remains. Therefore, there is no evidence of a specific tool kit linked to elephant site.

Secondly, elephants are never the only represented taxon, even in very well-preserved and short occupation contexts, and often with cut marks, indicating probably some more complex modalities of occupation than previously thought. Indeed, the image of the opportunistic and casual exploitation on a very short time of a single carcass by human groups is not supported by data. This is also discernible in the lithic assemblages, that testify anticipating techno-economical strategy.

However, if clear evidence of elephant carcass exploitation is lacking, several weak indicators (transport of portion of the carcass, fracture on the bones, simple tool making) converge to indicate that elephants played an important role in the site, maybe like a mile-stone in the territory, or an attraction point.

This observation may indicate that in order to go further in the investigation of the relationships between humans and elephants we need to take into account other components (human and no human) of the associated environment. And that the human and elephant pair can rather be thought as a prism to understand the cultural and behavior variability.

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11. THE LA PRELE MAMMOTH SITE, CONVERSE COUNTY, WYOMING, USA

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KEYWORDS | Clovis; New World colonization; mammoth hunting; campsite; Palaeoindians

ABSTRACT

The La Prele Mammoth site is a Clovis archaeological site in Converse County, Wyoming (U.S.A.) that preserves chipped stone artifacts in spatial association with the remains of a subadult Columbian mammoth (*Mammuthus columbi*). The site was discovered in 1986 and initially tested by George Frison in 1987, but work ceased there until 2014 due to a disagreement with the landowner. In the intervening years, questions arose as to whether the artifacts and mammoth remains were truly associated, and the site was largely dismissed by American archaeologists. Recent excavations have not only demonstrated that La Prele was the location of a mammoth kill by Clovis hunters around 12,850 years ago, but it also preserves a campsite in close proximity to the kill. The camp includes multiple hearth-centered activity areas that appear to represent domestic spaces, reflected by the presence of a diversity of stone tool forms, bone needles, a bone bead, a large area of hematite-stained matrix, and the butchered and cooked remains of at least one other large mammal species. The site has the potential to inform us about aspects of the social organization of Clovis bands, particularly with respect to mammoth hunting and butchery.

11.1 INTRODUCTION

From the Middle Pleistocene and continuing to nearly the onset of the Holocene, evidence for the predation of proboscideans in the archaeological record is concentrated at the edges of human global existence, where the range of *Homo* intersected with those of species in the order Proboscidea (Surovell et al., 2005, 2016). In the Old World, sites showing clear hominin interaction with proboscideans migrate slowly to the north and east as the geographic range of the genus *Homo* expands in the same direction. Outside of Africa, Lower Palaeolithic sites with direct evidence of the exploitation of proboscideans concentrate in the Mediterra-

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nean zone, but also as far north as southern Great Britain (e.g., Goren-Inbar et al., 1994; Yravedra et al., 2010; Anzidei et al., 2012; Rabinovich et al., 2012; Wenban-Smith, 2013; Boschian and Saccà, 2015; Panagopoulou et al., 2018; Espigares et al., this volume; Wenban-Smith, this volume). Middle Palaeolithic sites are found from the Channel Islands (U.K.) and France in the west to Germany in the east (e.g, Gaudzinski, 2004; Cliquet, 2008; Scott et al., 2014). Direct evidence for hunting of proboscideans is found farther east and north in the Upper Palaeolithic, in areas of Eastern Europe and Siberia (e.g., Zenin et al., 2003; Nuzhny et al., 2014; Sinitsyn et al., 2019; Wojtal et al., 2019). This pattern continues in the New World. When humans entered the Americas after the Last Glacial Maximum, a temporally brief, but spatially extensive record of exploitation of mammoths, mastodons and gomphotheres is evident in the centuries surrounding 13,000 BP (e.g., Haury, 1953; Haury et al., 1959; Leonhardy and Anderson, 1966; Warnica, 1966; Graham et al., 1981; Frison and Todd, 1986; Nuñez et al., 1994; Haynes and Huckell, 2007; Surovell and Waguespack, 2008; Sanchez et al., 2014; Hannus, 2018; Mothé et al., 2020). This pattern in time and space provides a unifying thread tying together the records of the Old and New Worlds, and suggests that not only did modern humans and our hominin relatives regularly prey upon taxa in the order Proboscidea when the opportunity was available, but also that we very likely contributed to the extinction of these animals over much of their range (Martin, 1984; Martin and Steadman, 1999; Surovell et al., 2005, 2016; but see Grayson and Meltzer, 2002, 2015).

Successful proboscidean hunts present a series of technical and logistical challenges that are largely unique to animals of massive body size (Johnson et al., 1980; Byers and Ugan, 2005; Bird et al., 2013; Lupo and Schmitt, 2016; Agam and Barkai, 2018; Ichikawa, this volume; Lewis, this volume; Yasuoka, this volume). As Surovell and Waguespack (2009) have observed, the difference in body mass between hunter and proboscidean prey can be two orders of magnitude or more. Although humans have developed several solutions to address the large difference in body size between themselves and elephants (Johnson et al., 1980; Agam and Barkai, 2018), other animal species have not. Elephant hunting is almost exclusively a human activity (but see Power and Compion, 2009).

Logistical challenges attend the process of efficiently using the bonanza of food produced by elephant hunts, which produce an estimated 2,000,000 kcal, or enough to feed 30 people for more than a month (Lupo and Schmitt, 2016). Processing a yield this large requires large numbers of people working long hours (Byers and Ugan, 2005; Lupo and Schmitt, 2016). In such cases, it can be more energetically efficient to move a camp to the site of a kill (e.g., Turnbull, 1962; Bailey, 1989; Fisher, 1992, 1993; Duffy, 1995; Ichikawa, this volume), as opposed to transporting the kill back to camp. Successful elephant hunts thus present one case in which the human tendency for central place foraging can break down, and human mobility patterns mimic those of other large predators where consumers move to kills.

Direct evidence for humans overcoming the technical challenge of proboscidean hunting is sometimes found in the archaeological record, but archaeological evidence for the human solutions to logistical challenges attending proboscidean hunts is less common. Humans answered the technical challenge of proboscidean hunting by producing large, sharp weapons used by groups of hunters, and weapons of this sort are found in proboscidean bone beds throughout the world. In Eurasia, for example, wooden spears and lithic and osseous projectile tips have been recovered from sites containing proboscidean remains (Movius, 1950; Zenin et al., 2003; Nuzhny et al., 2014; Sinitsyn et al., 2019; Wojtal et al., 2019). In North America, kill sites of mammoths, mastodons and gomphotheres are typically found associated with fluted stone projectile points (e.g., Haury, 1953; Haury et al., 1959; Leonhardy and Anderson, 1966; Graham et al., 1981; Frison and Todd, 1986; Haynes and Huckell, 2007; Sanchez et al., 2014; Hannus, 2018) with a few possible

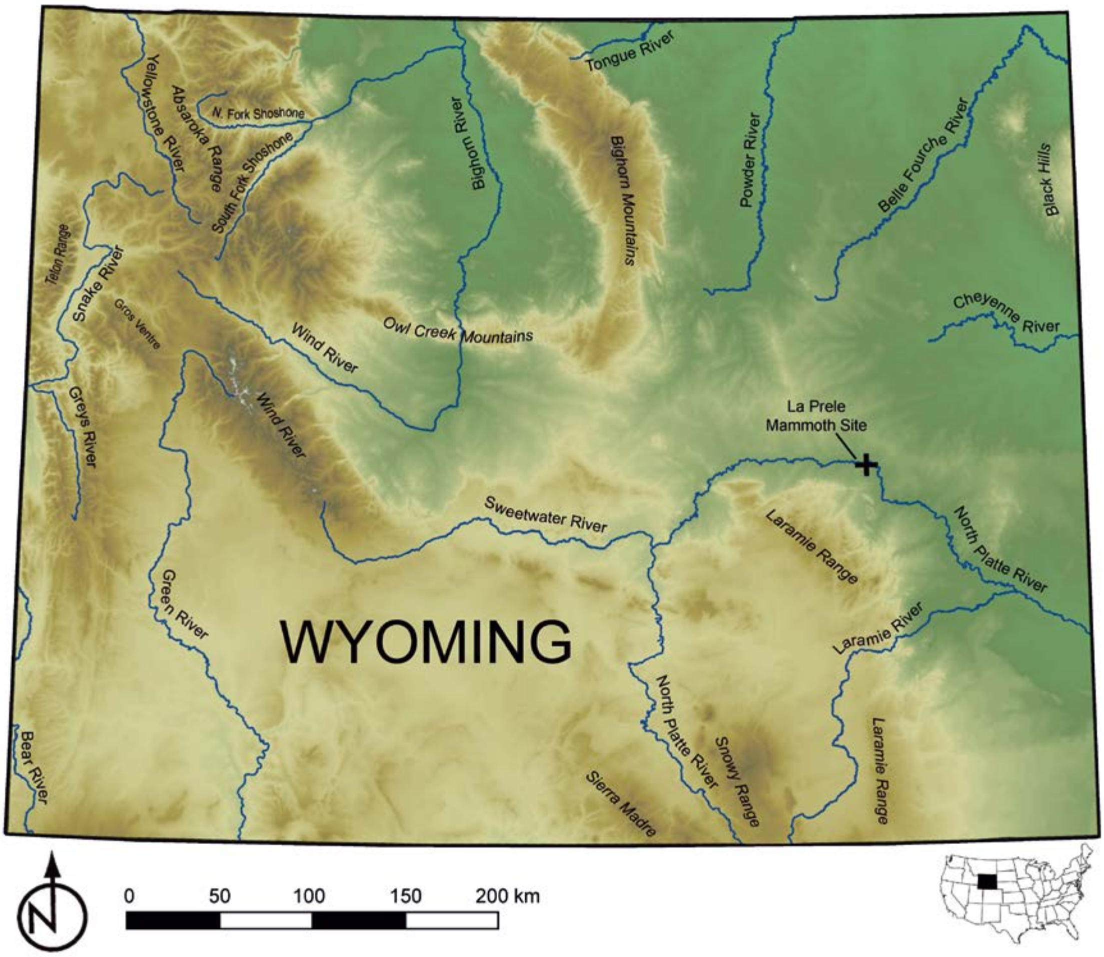

Figure 11.1: Map of the state of Wyoming showing the location of the La Prele Mammoth site relative to major rivers and mountain ranges.

exceptions (Aveleyra Arroyo de Anda and Maldonado-Koerdell, 1953; Gustafson et al., 1979; Waters et al., 2011), and an actualistic study has shown that such weapons are effective at penetrating elephant hide (Frison, 1989).

Archaeological evidence reflecting the human solutions to logistical challenges of elephant hunting and butchery should be present in the campsites associated with hunts, but those locations are seldom found in the archaeological record. Mammoth kill sites are typically just that, their spatial extents limited to the bonebed itself. In North America, there are two sites at which camps have been identified in association with proboscidean kills. At the Murray Springs site in southeastern Arizona (U.S.A.), a camp area was found more than 50 m away from the location of a mammoth kill (Haynes and Huckell, 2007). A similar situation exists at Fin del Mundo in western Sonora (Mexico), where a Clovis camp area occurs more than 500 m away from a Clovis gomphothere (*Cuvieronius*) kill locality (Sanchez, 2010; Sanchez et al., 2014).

In this paper, we introduce a third Palaeoindian site where proboscidean remains were found associated with a short-term camp, the La Prele Mammoth site in Converse County, Wyoming. This site was once largely dismissed by archaeologists as insignificant (Byers, 2002; Grayson and Meltzer, 2002; Cannon and Meltzer, 2004), but recent investigations have shown that it contains what is very likely a mammoth kill area associated with a camp space. Herein, we present a summary of the findings and major insights from the first five seasons of excavations (1987, 2014–2017).

Figure 11.2: Aerial photograph of the La Prele Mammoth site (dashed line) looking north. La Prele Creek is the stream in the foreground, and the valley of the North Platte River can be seen toward the top of the image.

11.2 SITE SETTING AND HISTORY OF INVESTIGATIONS

The La Prele Mammoth site was discovered in 1986 when two residents of Douglas, Wyoming, Bill Hinrichs and Mike Earnst, found mammoth bones in a cut bank of La Prele Creek (Fig. 11.1). At a large scale, the location of the site is quite understandable. The site occurs very close to a major pathway through the Rocky Mountains, the historic route of the Oregon Trail, which followed the North Platte to the Sweetwater River, leading to South Pass, a gap between the Southern and Central Rocky Mountains. La Prele Creek is a tributary of the North Platte, and the site sits 1.6 km upstream of their confluence. Not only did the Oregon Trail pass through the area, but so did the Bozeman Trail, and the Chicago and Northwestern Rail Line. The elevated fill of the now abandoned rail line as well as a wooden bridge built to cross the creek are directly adjacent to the site (Figs. 11.2, 11.3). Interstate 25 follows a similar route, but 6 km to the south. Just over 1 km to the north/northwest was Fort Fetterman, built by the United States Army in 1867 to protect migrants on the Bozeman Trail from hostile Native Americans. The Bozeman trail turned north from the Oregon Trail just to the south of the site. All of this is to say that the site occurs along a major travel corridor that allows low cost movement across the continent. For that reason, the general location of the site is predicted remarkably well by Anderson and Gillam's (2000) least cost pathway analysis of likely routes of New World colonization.

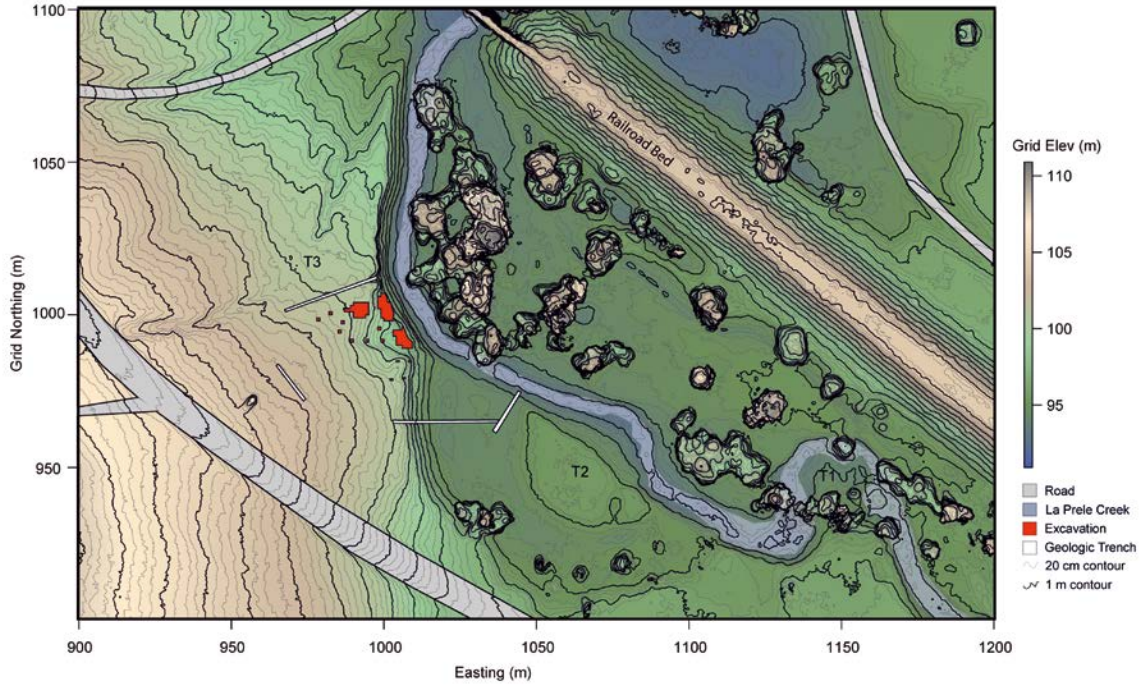

Figure 11.3: Topographic map of the La Prele Mammoth site made using structure from motion photogrammetry from drone aerial photography. Note that vegetation (trees and shrubs) appear as elevated areas within the lower areas of the La Prele valley. The railroad bed of the Chicago and Northwestern Rail Line can be seen running from southeast to northwest.

However, when the site's location is considered at smaller scales, it occurs in a rather unexceptional location. The occupation is buried ~3 m beneath the surface in an alluvial terrace containing a single occupation dating to the Clovis period (13,100 to 12,700 BP), even though some 6,000 years of overlying Late Pleistocene and Holocene deposits have the potential to, but do not contain prehistoric occupations. There are also pre-Clovis sediments at the site, but they are archaeologically sterile. Though the site sits next to a perennial stream and near its confluence with a major river in the area, this specific location was not a place humans used repeatedly. That is likely because the creek itself flows continuously over a distance of more than 40 km out of the Laramie Range before entering the North Platte, which itself flows continuously for hundreds of kilometers out of Colorado, through Wyoming, and into Nebraska, where it joins the Missouri. In other words, there are many good places to live, camp or do other things in the nearby area such that the exact site location was anything but magnetic.

George Frison learned of the discovery of the mammoth remains in the spring of 1987 and excavated a ~3 × 4 m excavation block at the site. At the time, the site was called the Hinrichs Mammoth, named after one of its discoverers. Frison and crew recovered nine flakes, a hammerstone and one unifacial tool in association with much of the axial skeleton of a subadult Columbian mammoth (Fig. 11.4). The head and mandible were not recovered, although tooth enamel plates were found on the actively eroding bank. Parts of the rib cage remained in anatomical position and the mammoth, though somewhat dispersed, was more or less in anatomical order with the anterior skeleton to the south and the posterior to the north. An abstract on the site was published for the 1988 meeting of the American Quaternary Association (Walker et al., 1988), but additional fieldwork was prohibited after a disagreement with the landowner. In 2002, David Byers, then a graduate student at the University of Wyoming, published a taphonomic and geoarchaeological analysis of what was renamed the Fetterman Mammoth us-

Figure 11.4: The mammoth bone bed from the 1987 Frison excavations, looking northwest. The photographic scale is 1 m in length.

ing the assemblage and available field notes (Byers, 2002). Based partly on slight differences in elevation between four mapped artifacts and the reconstructed surface on which the mammoth remains rested, Byers (2002: p. 437) questioned whether the artifacts and bones were truly associated: "The analysis presented here suggests that the lithic artifacts may not be contextually associated with the faunal assemblage. Instead the cultural materials could have been deposited at the site well after the mammoth died…" Because of Byers's (2002) analysis, the site was largely dismissed as insignificant (e.g., Grayson and Meltzer, 2002; Cannon and Meltzer, 2004).

In 2014, we learned that we had an opportunity to return to the site, and we did so with the University of Wyoming Archaeological Field School. Our primary intent was to further examine the question of whether there was a true association between the mammoth and cultural materials. To that end, we excavated nine 1 × 1 m units surrounding Frison's excavations and gave the site its third, and hopefully final name[1], the La Prele Mammoth site. A chance find of a chopper eroding from the cut bank 12 m south of the mammoth suggested the presence of a second activity area in the same stratum as the mammoth. From 2015 through 2017, our excavations expanded to new areas of the site, and as they did, so did our understanding of it. Additional work showed unquestionably that the artifacts and mammoth remains are associated (Mackie et al., 2020). From 1987 to today, our understanding of the site has morphed from a likely mammoth kill site to a possible accidental association of Pleistocene arti-

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[1] Frison originally named the site after Dr. William Hinrichs, one of the two individuals who discovered it. When a dispute arose with the landowner, it was decided that a more neutral name should be chosen, so the site was deemed "Fetterman", after nearby Fort Fetterman. Fort Fetterman was named after William J. Fetterman, an officer in the United States Army, who was killed in action in 1867 along with 80 individuals under his command in a battle with the Oglala Chief Red Cloud and a huge party of Arapaho, Cheyenne, and Lakota warriors. Because the site had nothing to do with Fetterman (who died more than 200 km away), we renamed the site after the creek on which it sits.

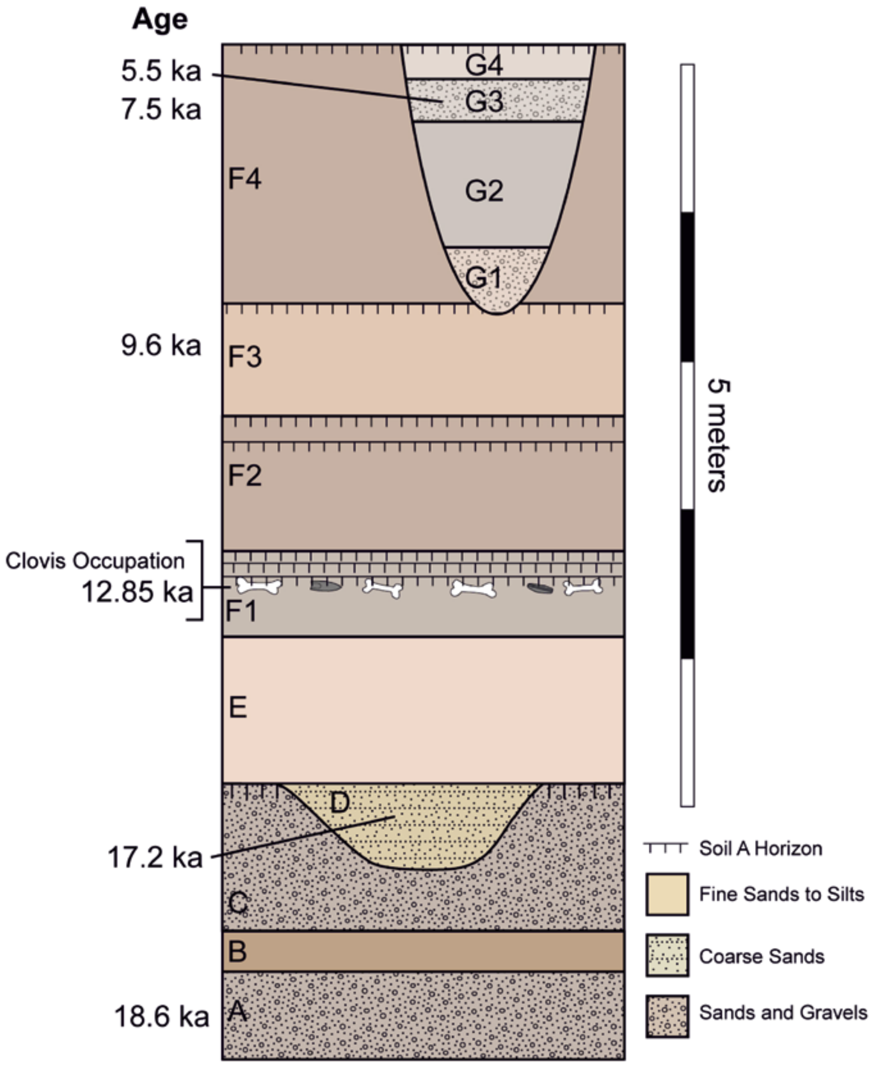

Figure 11.5: Generalized stratigraphic profile of the excavation area.

facts and megafauna to what is almost certainly a mammoth kill and associated campsite preserving multiple hearth-centered activity areas flanking the bonebed.

11.3 GEOLOGY, AGE AND SITE FORMATION

The Clovis occupation is buried approximately 3 m beneath the ground surface in alluvial deposits within the third terrace of the La Prele Creek. A generalized stratigraphic profile of T3 is presented in Figure 11.5. Bedrock in the immediate site area includes sedimentary rocks of the Palaeocene Fort Union Formation, which includes coal beds, and particulate coal makes up a recognizable fraction of the alluvial deposits of La Prele Creek, something which has likely affected some radiocarbon dates at the site. The oldest dates (OSL ages) we have on bedload alluvium (Stratum A) near the base of the third terrace suggest aggradation began over 18,000 years ago, probably around or just after the Last Glacial Maximum. Fine-grained alluvial deposition indicating periodic overbank events begins with Stratum E and continues through Strata F1 to F4, although it is possible that Stratum E represents a local facies of Peoria loess (Mason et al., 2008), whether primary or secondary. A series of buried soils mark brief episodes of stability fol-

Lab Number	Material	Fraction	Taxon	Area	Conv. 14C Age (BP)	∆13C	1Σ Cal. Age (BP)
CAMS-74661	bone collagen	XAD-gelatin hydrolyzate	mammoth	Block A	8,890 ± 40		10,028 ± 88
CAMS-72350	bone collagen	gelatin	mammoth	Block A	9,060 ± 50		10,223 ± 46
OxA-36958	bone collagen	ultrafiltered collagen	mammoth	Block A	9,320 ± 45	-19.5	10,523 ± 68
AA108894	bone collagen	ultrafiltered collagen	large mammal	Block B	10,654 ± 58	-17.9	12,623 ± 49
UCIAMS-40174	bone collagen	gelatin	mammoth	Block A	10,760 ± 30		12,699 ± 10
AA108895	bone collagen	ultrafiltered collagen	large mammal	Block B	10,776 ± 59	-16.4	12,696 ± 31
UCIAMS-206764	bone collagen	XAD-gelatin hydrolyzate	mammoth	Block A	10,965 ± 30		12,796 ± 36
OxA-X-2736-14	bone collagen	hydroxyproline	mammoth	Block A	11,035 ± 50	-22.7	12,900 ± 68
AA108893	bone collagen	ultrafiltered collagen	mammoth	Block A	11,066 ± 61	-20.3	12,926 ± 74
AA107104	calcined bone	apatite carbonate	unknown	Block B	11,190 ± 130	-23.0	13,036 ± 135
AA109297	calcined bone	apatite carbonate	unknown	Block B	13,997 ± 90	-19.7	16,991 ± 140

Tabelle 11.1: Direct radiocarbon dates on the Clovis occupation at the La Prele Mammoth site.

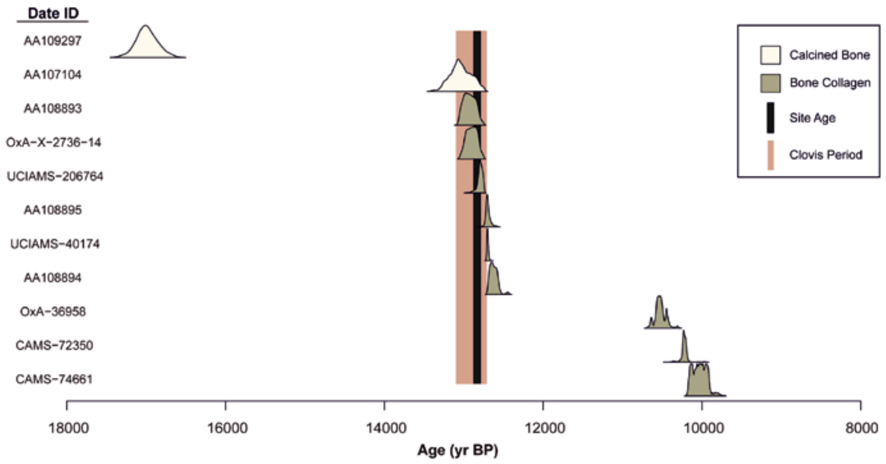

Figure 11.6: Direct dates on the Clovis occupation. All ages are calibrated radiocarbon age distributions. Rectangles indicate the Clovis period (brown) and a 2σ age estimate of the occupation of the site.

lowing flood events. A cut and fill dating to around 5,000 to 6,000 BP removed stratum F4 in places including the site area, after which the stream incised downward leaving the T3 surface on valley margins. Aggradation in the valley appears to have not occurred again until sometime after 3,000 BP.

The Clovis occupation occurs within Stratum F1. In most of our excavation areas, the archaeology sits at the base of a heavily bioturbated and thick mollic A-horizon that in other parts of the site separates into two or three thin A-horizons (Fig. 11.5). The mammoth remains themselves are heavily weathered on the upper surfaces (Byers, 2002; Fig. 11.4), suggesting they sat on the surface probably for a number of years prior to being buried by a few small flood events. The formation of these palaeosols post-date the Clovis occupation by decades to a few centuries. Intensive bioturbation coupled with a robust microfauna record that includes rodents, birds and gastropods, suggest that like today a rich riparian zone occurred on the floodplain of La Prele Creek in the area in the terminal Pleistocene (Fig. 11.2). Bioturbation caused significant upward and downward dispersal of cultural materials (Mackie, 2019; Mackie et al., 2020), which explains Byers's (2002) finding that a few of artifacts recovered in early excavations were found at slightly higher level than the mammoth bone.

We have produced more than 50 radiocarbon and OSL dates from the site area (Mackie et al., 2020), but for the purpose of this paper, we only present those most relevant to estimating the age of the occupation. A total of eleven radiocarbon dates have been produced on mammoth and other large mammal bone collagen or calcined bone from the site (Table 11.1, Fig. 11.6). Initial dates produced on collagen from mammoth bone (Byers, 2002) were anomalously young and post-dated mammoth extinction in North America by more than 2,000 years. These are not the only anomalous dates on the site, however. More recent dating efforts have also produced dates that are both too young and too old for a Clovis site (Waters and Stafford, 2007; Devièse et al., 2018; Mackie et al., 2020). Seven of the radiocarbon ages cluster within a fairly narrow range from ca. 12,600 to 13,000 BP. Because bone collagen dates when in error are usually too young, we estimate the age of the site using the four oldest ages within this cluster. Those dates form a statistically homogenous grouping and include one date on calcined bone (AA109297, 11,190 ± 130 BP), one on ultrafiltered collagen (AA108893, 11,066 ± 61 BP), two dates from Devièse et al. (2018), a collagen hydroxyproline date (OxA-X-2736-14, 11,035 ± 50 BP) and an XAD hydrolysate collagen date (UCIAMS-206764, 10,965 ± 30 BP). After calibration using the BChron package v. 4.3 (Haslett and Parnell, 2008) for R v. 3.6.2 (R Core Team, 2019) and the IntCal13 calibration curve (Reimer et al., 2013) and averaging using the Long and Rippeteau (1974) method, we estimate the age of the Clovis occupation to be 12,846 ± 29 cal BP.

11.4 SITE DESCRIPTION

Excavations at La Prele between 2014 and 2017 were conducted in three Blocks (A through C) and twelve test units for a total of around 96 m^2 of excavation completed as of 2017. Excavations have sampled an area of 29 m north to south by 29 m east to west, establishing a minimum site area of 530 m^2. Our recent excavations use the grid that Frison established in his test excavations. Post-1987 excavations were completed in 50 × 50 cm quadrants within 1 × 1 m excavation units. We excavated all units in 5 cm arbitrary levels and water-screened all excavated sediments through 1/16 inch (1.6 mm) mesh. Because the chipped stone assemblage is dominated by very small (<5 mm in maximum dimension) flakes, most artifacts are found in the screen. Screens are picked in the field and again in the lab. Lab picking of screen matrix is ongoing, so artifact counts presented are preliminary. An overview map of excavations is presented in Figure 11.7, and photographs of artifacts are shown in Figure 11.8.

11.4.1. BLOCK A

Block A contains direct evidence of mammoth hunting[2] by Clovis foragers, including the partial remains of a single subadult Columbian mammoth and associated stone artifacts. The mammoth bonebed primarily contains the ribs and vertebrae of the axial skeleton, but also contains small

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[2] We acknowledge the possibility that the mammoth was scavenged but consider it much less likely than hunting.

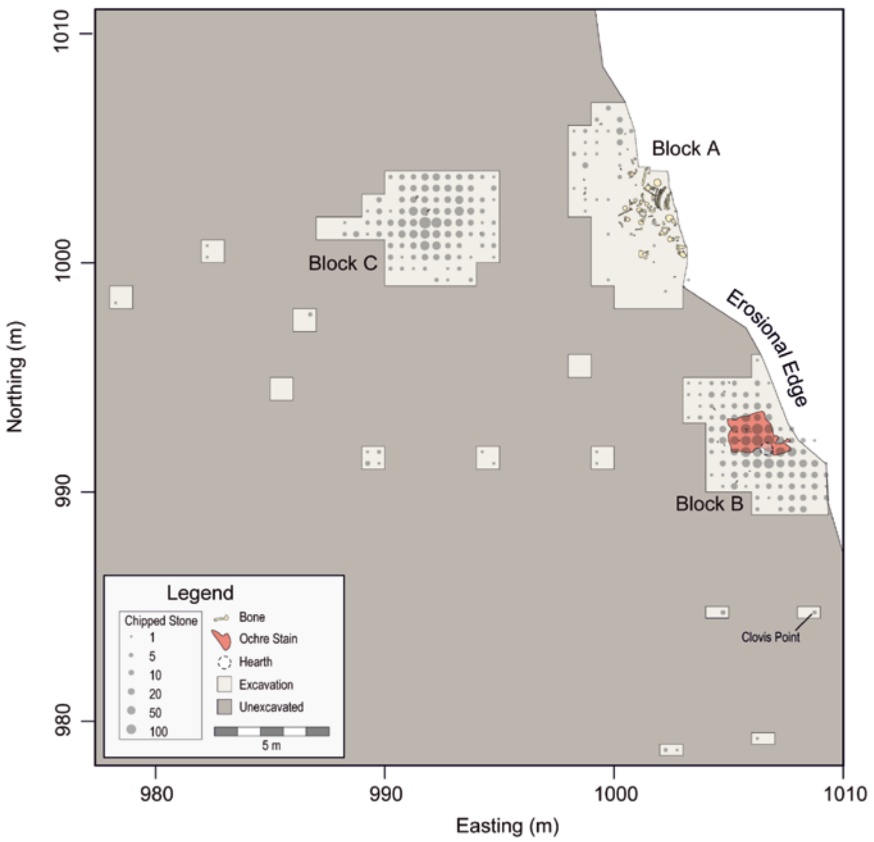

Figure 11.7: Plan map of excavations the La Prele Mammoth site showing major excavation areas, features, large pieces of mapped bone and chipped stone artifact counts.

portions of both the anterior and posterior appendicular skeleton, including a scapula, phalanx and at least one as yet unidentified appendicular element (Byers, 2002). The eastern margin of Block A is truncated by erosion caused by La Prele Creek, which likely removed most appendicular elements and the cranium in the recent past. Sided elements present in the bonebed (i.e., ribs and scapula) are almost invariably from the right side of the skeleton, and the skeleton is loosely arranged in anatomical position with the cranial portion facing the south-southeast and caudal portion facing the north-northwest. Because it remains mostly in anatomical order, the mammoth likely has moved little from its place of death. Given depositional and weathering evidence that the skeleton was exposed for some time prior to burial, the left side of the skeleton was most likely removed due to post-depositional processes such as erosion, weathering, or human or carnivore transport, while the right side was buried prior to disturbance.

Mammoth remains are directly associated with a sparse chipped stone flake scatter not exceeding 32 flakes per m^2, a unifacially-retouched flake tool (Fig. 11.8d) and a hammerstone. Flake raw materials subsume a modest variety of quartzites and cherts derived from at least two source areas, including the Hartville Uplift region of eastern Wyoming, around 80 km southeast of La Prele, and areas in western or southwestern Wyoming in which cherts of the Green River Formation crop out, at least 250 km west and/or southwest of La Prele. The single flake tool is unifacially retouched along one lateral margin and resembles cherts derived from the Eocene Green River Formation. The hammerstone is a small river cobble that has one flake removal on its end but otherwise lacks signs of battering. As a large cobble-sized clast, it was out of place in otherwise fine-grained site matrix. Flakes are relatively abundant in the northern portion of Block A, around the posterior portion of the mammoth

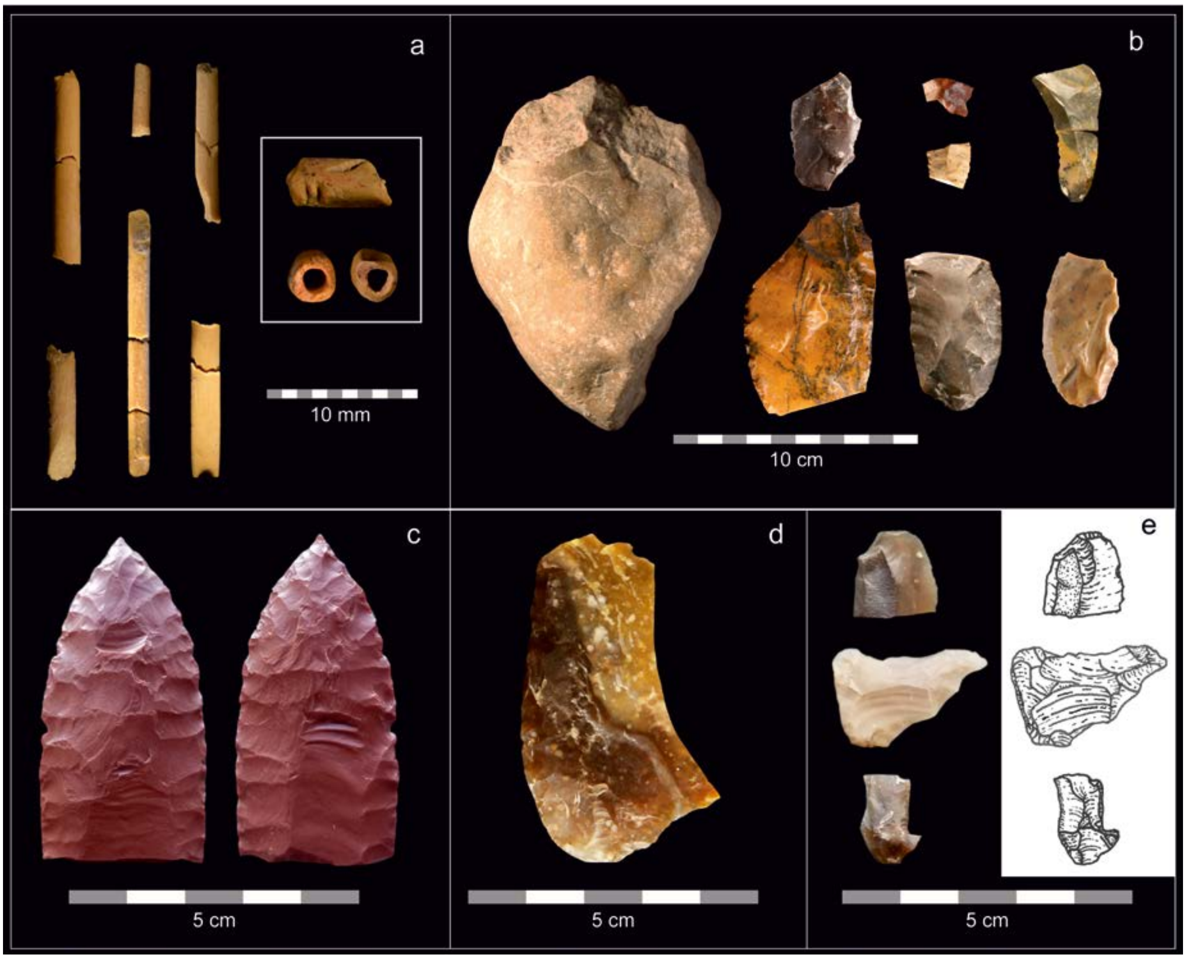

Figure 11.8: Tools from the La Prele Mammoth site including **(a)** bone needles and bead from Block B, **(b)** the chopper and flake tools from Block B, **(c)** Clovis point from a test unit, **(d)** flake tool from the mammoth bonebed in Block A, and **(e)** tools from Block C.

remains. Burned flakes (i.e., crazed and potlidded) in the northern portion of Block A suggest the presence of a controlled fire, but no hearth was discerned during excavation.

11.4.2. BLOCK B

Block B contains a hearth-centered activity area that may have incorporated a dwelling whose center is located around 10 m south-southeast of the Block A mammoth (Mackie et al., in press). Block B contains at least three bone needles, a bone bead, eight stone tools, more than 1,000 flakes, large mammal bone, and a red ocher stain. Block B flakes reach a maximum density of around 300 flakes per m^2 near the center of the block. There was no evidence observed during excavations for a hearth nor a dwelling, but the spatial distribution of flakes, bone and ocher in Block B was used by Mackie et al. (in press) as a means of estimating the location of a hearth-centered dwelling. The structure likely measured around 3 m in diameter and the northeastern one-third was truncated by erosion. A 3.2 m^2 red ocher stain subsumes the northwest portion of the dwelling (Fig. 11.7), extending from the edge of the hearth to the northwest edge of the dwelling. Nodules of red ocher extend beyond the margins of stained sediment and were recovered in large numbers from all areas of Block B. The dwelling contains fragments of at least three very thin bone needles, typical of those of the Palaeoindian period (Frison and Craig, 1982; Lyman, 2015; d'Errico et al., 2018) and an incised bone bead derived from an unknown species. The needles and bead represent some of the earliest dated examples of these objects from North America (Holliday and Killick, 2013; Osborn, 2014; Lyman, 2015).

Block B contains seven chipped stone flake tools and a large, expediently-produced cobble chopper. Chipped stone tools exhibit a wide variety of edge modifications, including graver tips, concave spoke-shave/notch margins, denticulated margins, long steeply-retouched unifacial margins and the steeply-retouched "bit" end of at least one endscraper (Fig. 11.8). The cobble chopper is a large, locally-procured cobble with three large flakes taken off one end to form a sharp chopping tool. All identified chipped stone raw materials from Block B (except the cobble chopper) are cherts and quartzites derived from the Hartville Uplift around 80 km southeast of La Prele. The red ocher from Block B was also geochemically-sourced to the Hartville Uplift (Zarzycka et al., 2019), rounding out a cohesive raw material procurement pattern for Block B.

Block B contains a small number of fragmented large mammal bones, tentatively identified through ancient DNA analysis as *Bison* sp. (Mackie, in press). Although most large specimens are unidentifiable long bone fragments, comparative analysis indicates the presence of non-mammoth archaeofaunal remains. In total, three rib fragments were identified with one rib neck present, two vertebral spinous processes, a radius, a metapodial and a molar. Only the enamel from Block B can be definitively assigned to *Bison* sp., as can a near complete lumbar vertebra from Block C. Although the remaining elements are likely bison, the degree of weathering and fragmentation cannot exclude other similarly sized large mammals (e.g., perissodactyls or artiodactyls). Impact-fractured long bone fragments alongside small pieces of calcined and carbonized bone indicate subsistence use of at least one large mammal species other than mammoth.

11.4.3. BLOCK C

Block C incorporates a circular, approximately 5 m wide, hearth-centered activity area whose center is located around 12 m west of the Block A mammoth. Block C contains the densest concentration of artifacts thus far discovered at La Prele, with flake densities reaching around 440 per m^2. Comparable to Block B, no hearth was observed during excavation of Block C, but clustering of burned artifacts near the dense center of the flake scatter strongly suggests the presence of a phantom or invisible hearth (Sergant et al., 2006; Alperson-Afil et al., 2009). Block C tools include four use-retouched flake tools, which are generally more expedient in comparison to those recovered from Blocks A and B (Fig. 11.8e); they are also small in size, like those described by Marinelli et al. (this volume). Most Block C chipped stone is a translucent, brown chalcedony most likely derived from the Green River Formation. In support of a Green River Formation provenance, a single oolitic chert flake from Block C is characteristic of a source area in the area of Farson, Wyoming. Block C contains a small number of faunal specimens, the most notable of which are a mostly complete *Bison* sp. fourth lumbar vertebra and a large long bone fragment. Burned bone fragments are also present.

11.4.4. TEST UNITS

Eight 1 × 1 m and four 0.5 × 1 m test units delineate the known extent of La Prele toward the southwest and suggest the presence of additional artifact clusters comparable to Blocks B and C. Ten of twelve test units yielded chipped stone artifacts. Chipped stone flakes exist at a maximum density of 12 per m^2 in a 1 × 1 m test unit around 13 m west of Block B and 7 m south of Block C. Test unit raw materials are largely derived from Hartville Uplift chert and quartzite, but a test unit 4 m west of Block C contains Green River Formation chert and the furthest west test unit contains both Green River Formation chert and a single quartzite flake. The most significant test unit artifact is the distal end of a Clovis point discovered 4 m south of Block B (location shown on Figure 11.3). The Clovis point is fluted on both faces and contains a small amount of grinding on one edge in preparation for hafting (Fig. 11.8c). The point is produced from a homogenous opaque red chert, potentially from the Phosphoria or Goose Egg Formations, which crops out widely in north-central Wyoming, anywhere between 100 and 300 km from La Prele.

11.5 SUMMARY AND CONCLUSIONS

Over the 30 years of investigations at La Prele, each year of excavation yields surprising new empirical insights. Frison was surprised in 1987 when his excavations showed that what first appeared to be palaeontological remains of a mammoth were associated with chipped stone artifacts. Our renewed investigations in 2014 yielded the surprising finding that the site extends well beyond the bonebed, as evidenced by the presence of a chopper in stratigraphic association with the mammoth, a relatively common tool type found in Clovis mammoth sites (Haury et al., 1959; Frison and Todd, 1986; Haynes and Huckell, 2007). A large, red ocher stain with associated domestic artifacts was yet another surprise and may be unique to La Prele in comparison to other mammoth kill sites in the Palaeoindian record and to other proboscidean kill sites globally. The realization that clusters of artifacts surrounded the mammoth surprised us yet again, opening the door to the possibility that each cluster represents a distinct household unit.

Although our investigations at La Prele have been surprising at every turn, the cumulative results are exactly what one might expect of a highly mobile, mammoth-hunting population (Kelly and Todd, 1988) traversing the North American continent along major least-cost pathways (Anderson and Gillam, 2000) during the earliest period of New World colonization. La Prele provides an uncommon glimpse into the way Clovis foragers solved the logistical challenges of mammoth hunting in the New World, and it fits many of the traditional ideas of Clovis adaptations (e.g., Haynes, 1966, 1969; Martin, 1973; Kelly and Todd, 1988).

As expected of successful proboscidean hunts (e.g., Turnbull, 1962; Bailey, 1989; Fisher, 1993; Duffy, 1995; Ichikawa, this volume), Clovis foragers appear to have moved their campsites to the kill in order to butcher the mammoth for its meat and fat, solving the logistical challenge of efficiently processing a proboscidean kill. At least one of the multiple clusters surrounding the La Prele mammoth appears to represent the remnant of a hearth-centered, ephemeral dwelling. Clovis foragers also appear to have maintained a large network of social ties to facilitate mammoth hunting, meeting the logistical challenge of amassing enough people to stage a successful hunt. Raw materials from La Prele span at least 350 km, suggesting social ties across distances spanning most of the state of Wyoming. Further, Clovis foragers at La Prele maintained a highly formal chipped stone toolkit and practiced extremely conservative stone tool use on site, a solution to the challenge of maintaining a lithic toolkit while living a highly mobile existence (Meltzer, 1984; Kelly and Todd, 1988; Goodyear, 1989; Amick, 1996; Surovell, 2000, 2009). Although flakes are abundant, they rarely exceed 1 cm in length, and are indicative of resharpening formal tools.

Beyond addressing some long-standing questions regarding the logistical challenges of mammoth hunting in the New World, we are excited by the prospect of La Prele providing a window into the social challenges of mammoth hunting, the largest among which might have been dividing hunt spoils among participants. Such sudden and enormous influxes of caloric wealth can be leveraged by hunters to gain social prestige, but they can also be the source of conflict when the spoils of a hunt are to be divvied up (Hawkes, 1991; Hawkes and Bliege Bird, 2002; Lewis, 2002; Bird et al., 2013; Lupo and Schmitt, 2016; Yasuoka, this volume). Given that raw materials are segregated by artifact cluster at La Prele, we are optimistic that further excavations of artifact clusters will identify inter-cluster differences in tool constituents, faunal remains, and other characteristics that might provide a window into the social dynamics at play during the La Prele mammoth hunt nearly 13,000 years ago.

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3

Elephants in past human nutrition

12. SUPERSIZE DOES MATTER: THE IMPORTANCE OF LARGE PREY IN PALAEOLITHIC SUBSISTENCE AND A METHOD FOR MEASURING ITS SIGNIFICANCE IN ZOOARCHAEOLOGICAL ASSEMBLAGES

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ABSTRACT

Humans consumed megaherbivores, including proboscideans, throughout the Pleistocene. However, there is a high potential for underappreciation of their relative importance to humans' economy due to their potential relative underrepresentation in Palaeolithic archaeological sites. Relying on our previous work, we discuss the critical importance of large animals in human prehistory. We review four factors that made megaherbivores critically important to humans: high ecological biomass density, lower complexity of acquisition, higher net energetic return, and high fat content. We propose a model that intends to overcome the potential underrepresentation bias by multiplying the MNI (Minimum Number of Individuals) of each animal species by its weight and only then determining the relative biomass abundances. The next step of the model is the accumulation of the relative biomass abundance, beginning with the largest animal. This step enables a comparison of various assemblages in the relative complexity of acquisition, the level of net energetic return, and the level of fat content in the prey. We successfully test the method on an actualistic case of 61 hunts of the Hadza, where the true number and the MNI are known. We then apply the method to three comparisons between two successive cultural periods each, in the Levant, East Africa and Southern France. We find that there is indeed great potential for the underrepresentation of megaherbivores in the analysis of Palaeolithic faunal assemblages. Since the largest animal in our actualistic study was a giraffe, we propose a future avenue of research for better correction of the underrepresentation of elephants, which often have partial to no representation in central base sites.

12.1 INTRODUCTION

Humans and animals shared habitats across the Old and New Worlds throughout the long presence of the human race upon the earth. Before

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the advent of agriculture, humans were heavily dependent on animals for their survival, as is clearly shown by the dominance in prehistoric archaeological sites of bones and stone tools, both bearing marks of anthropogenic exploitation of animals for food. Animal resources were essential, first and foremost, in supplying humans with the daily caloric intake and nutritional needs, but also in providing materials for utensils, construction, clothing, and hunting gear.

The Pleistocene global-scale extinctions of many of the large terrestrial mammals that humans used to consume have been a major ecological phenomenon (Barnosky et al., 2004; Sandom et al., 2014; Potts et al., 2018; Smith et al., 2018, 2019a; Faith et al., 2019). The extinction of the larger animals continued into the Holocene (Dirzo et al., 2014). The role of humans in the extinction is highly debated, yet, discussion of the implications of the extinctions on humans are less prominent in the literature.

This paper aims to propose a hypothesis outlining the potential importance of large animals, particularly megaherbivores and proboscideans, in humans' subsistence during the Pleistocene and the implications of their extinction and disappearance. We propose a method of measuring the significance of large game in faunal assemblages and identify cases of probable stress to humans, caused by the disappearance and extinction of megaherbivores. Likewise, we argue that these extinctions led to changes in vegetal and faunal relative biomass, as well as in large prey's relative abundance (Johnson, 2009; Bakker et al., 2016; Faith et al., 2019), and thus necessitated appropriate changes in human behavior and modes of adaptation (Ben-Dor, 2018: chapter 5.3; Ben-Dor and Barkai, 2020).

A bias might occur between the surviving archaeological evidence on-site and the actual original fauna retrieved and processed by early humans, as archaeological faunal assemblages are affected by many parameters, such as body part transportation, distance from the kill sites and preservation issues. In order to confront such a bias, we analyze an actualistic ethnographic case study in an attempt to discern the degree of bias against the expected proper representation of large prey in Palaeolithic faunal assemblages. We then propose and test a methodology to partially reduce the bias. We apply the method to three archaeological case studies where sufficient data exist to compare two consecutive Palaeolithic cultural phases in the same region and draw conclusions regarding human behavior in the face of changing faunal availability and representation, based on our hypothesis. We conclude by highlighting the underrepresentation of proboscideans in Palaeolithic assemblages, as inferred from the model and propose future research to better account for this.

Typically, a lower percentage of megaherbivores' complete body parts are transported to a central place, due to their higher weight and the probable long distances from the place of acquisition to the central place (Bunn et al., 1988; O'Connell et al., 1990). The butchery of a large game at the kill site and the transportation of soft tissue and fat to the central place will yield almost no identifiable archaeological signature at the locale of consumption [regarding elephants, see Lewis (this volume) and Yasuoka (this volume)]. Upon examining the evidence for Middle Palaeolithic diets, Morin et al. (2016) conclude that taphonomic and transport considerations may lead to underestimation of the contribution of large animals to the diet, especially megaherbivores. In Europe, there appears to be a significant mismatch between the considerable importance of mammoths in the Middle and Upper Palaeolithic diet, according to stable isotope analysis (Bocherens et al., 2005, 2013; Bocherens, 2011; Wißing et al., 2019; Bocherens and Drucker, this volume) compared with zooarchaeological analysis (e.g., Grayson and Delpech, 2002). Bocherens proposes that the mismatch between the zooarchaeological and isotopic dietary determinations may be due to taphonomic biases and site specialization (Bocherens, 2011: p. 73). Another explanation "could be linked to transport decisions: filleted meat of very large herbivores could have been transported to the camp and therefore did not leave as many bone remnants as those of less bulky prey species" (Bocherens, 2009: p. 247). The underrepresentation of megaherbivore bones in faunal assemblages may lead to an underappreciation of their economic importance to humans in the Palaeolithic and of the potential effect of humans on the extinction of megaherbivores and other large animals.

White (1953) proposed that to estimate the relative dietary contribution of species, the Minimum Number of Individuals (MNI) in an assemblage be multiplied by their consumable meat content to arrive at a biomass abundance index. However, biomass indexing of faunal assemblages is rarely performed in the analysis of Pleistocene faunal assemblages. Even in the rare cases, when biomass abundance index is calculated (e.g., Crader, 1984; Patou-Mathis, 2005), the animals are not sorted by size, so it is difficult to appreciate the contribution of large mammals versus smaller ones. Moreover, these studies usually do not address the behavioral and economic implications of the relative contribution of large prey [but see Guil-Guerrero (2017) regarding omega-3 fatty acids content of the diet]. Thus, a hypothesis regarding the reasons for the importance of acquiring large prey in the Palaeolithic can advance our ability to draw concrete adaptive predictions from identified changes in prey size composition in faunal assemblages. Testing and applying the hypothesis can lead to a better understanding of the role megaherbivores played in the cultural and biological history of humanity.

12.2 THE IMPORTANCE OF MEGAHERBIVORES IN PALAEOLITHIC SUBSISTENCE

Humans had access to large prey during most of the Pleistocene. Recent analyses of the archeozoological and palaeontological East African record portray *Homo erectus* as a habitual hunter of large prey (Domínguez-Rodrigo and Pickering, 2017; Roach et al., 2018). Preference for large prey animals during the Pleistocene is a conventional interpretation of archaeological assemblages (Isaac, 1984; Bunn and Ezzo, 1993; Bunn, 2006; Surovell and Waguespack, 2009; Domínguez-Rodrigo et al., 2014a). Large animals, including proboscideans, are a common feature in early African Pleistocene sites (Klein, 1988; Bunn and Ezzo, 1993; Domínguez-Rodrigo et al., 2014a, b) and early sites outside Africa, such as Ubeidiya, Latame, Gesher Benot Ya'aqov, Holon and Revadim in the Levant (Bar-Yosef and Belmaker, 2011; Ben-Dor et al., 2011), Dmanisi in Georgia (Gabunia et al., 2000; Bar-Yosef and Belmaker, 2011; Carotenuto et al., 2016), Marathousa 1 in Greece (Panagopoulou et al., 2018), Tarragona and Orce in Spain (Mosquera et al., 2015; Espigares et al., 2019), sites in central Spain (Yravedra et al., 2017), and Castel di Guido and La Polledrara in Italy (Saccà, 2012; Santucci et al., 2016), to mention only some of the most prominent Lower Palaeolithic sites. Moreover, it is evident that large animals, including proboscideans, continued to be an important component of archaeological sites worldwide throughout the Pleistocene (e.g., Zhang et al., 2010; Wojtal and Wilczyński, 2015; Pitulko et al., 2016; Yravedra et al., 2017; Demay et al., this volume; Rosell and Blasco, this volume).

Faurby et al. (2020) added a palaeontological angle to the hypothesis that humans preferred large prey. They hypothesized that, beginning in the Early Pleistocene, carnivorous activity of humans affected the diversity of other large carnivores. Werdelin and Lewis (2013) suggested that 1.5 million years ago, humans became members of the large carnivore guild, specializing in the acquisition of large herbivores, as evident by the extinction of sabretooth predators along with some hyenas [but see Faith et al. (2018) and reply to Faith et al. by Faurby et al. (2020)]. Additional support for humans' preference for large prey can be gained from the pattern of the extinction of large but not small animals in association with humans' introduction to previously unoccupied regions (Johnson et al., 2016; Saltré et al., 2016; Smith et al., 2019a), although other researchers emphasize the role of climate in these extinctions (Grayson and Meltzer, 2015). However, there is little argument that on islands, humans were responsible for the extinction of large animals (Duncan et al., 2002; Burney et al., 2003; Stuart, 2015; Cooke et al., 2017).

Although small animals were also acquired by humans in the Palaeolithic (Blasco and Fernández Peris, 2012; Blasco et al., 2016), an increase in the archaeological presence of smaller prey animals is evident in the Upper Palaeolithic in Eurasia, together with signs of increased plant food consumption (Stiner, 2002; Bar-Yosef, 2014). These changes are, intriguingly, temporo-spatially associated with the late Quaternary megafauna extinction (Barnosky et al., 2004).

A preference for large animals is also apparent in recent hunter-gatherers as they consistently accord the highest-ranking to larger prey (Broughton et al., 2011; Tanner, this volume). Based on their analysis of the Hadza men's hunting and sharing patterns, Hawkes et al. (2001) also noticed the preferential targeting of large prey. However, they attributed the preference to male costly signaling or "show-off" in order to attract mates. Speth (2010) reached a similar conclusion, associating big game hunting with male costly signaling rather than economics. Analyzing later data from the Hadza, Wood and Marlowe (2013) concluded instead that food economics rather than "show-off" was at the base of the Hadza men's hunting preferences, and Domínguez-Rodrigo et al. (2014a) reached a similar conclusion in a Palaeolithic context.

There are several reasons why larger, especially very large, animals are attractive to humans as prey, as we will discuss below.

12.2.1 WHY HUMANS PREFERRED TO ACQUIRE LARGE PREY

We propose that four factors made megaherbivores a primal target of human predation. The first is the high relative biomass density of megaherbivores. The second factor is their tendency to not escape from predators. The third is the higher net energetic return that is gained from their acquisition, and the fourth is their relatively high fat content. All these aspects may be inter-related. For example, high biomass is the cause of their higher energetic return and of not needing to escape from predators (Owen-Smith and Mills, 2008). Not needing to escape may enable the accumulation of higher fat content (Owen-Smith, 2002: p. 143).

We have to comment here on a paper by Lupo and Schmitt (2016) that claims that very large animals, like giraffes and elephants, are ranked among the lowest in terms of net energetic return (7th and 8th out of 8 animals in their table 4), because of their high acquisition and processing costs, and thus are acquired only in the framework of costly male signaling. It should be noted that their analysis is based entirely on general ethnographic data without actualistic or experimental support of a single complete case. The parameters they have used, namely, pursuit costs and hunting failure rates, are extremely sensitive to ecological conditions that, as previously discussed, were markedly different during the Pleistocene. Other parameters, like the need for preserving meat by smoking, are also assumed rather than evidenced or measured. For example, they consider all the 2.2 million calories of the elephant as subject to the costs of preservation and smoking. However, around 50% of the caloric estimation they present, or a million calories of the elephant energetic resources, are in the form of fat (Ben-Dor et al., 2011; Guil-Guerrero et al., 2018), which does not require smoking for preservation, for the most part. Likewise, a Pleistocene elephant was more likely to supply double the calories estimated in their paper (Ben-Dor et al. 2011), thus providing the hunting group with essential calories and fatty acids for weeks (Guil-Guerrero et al., 2018) and thus a surely prized food package (see Ichikawa, this volume; Lewis, this volume; Yasuoka, this volume). We recently argued that the Hadza and the San, and arguably most recent hunter-gatherer groups, were adapted technologically and behaviorally to hunt small game rather than megaherbivores, due to the massive global decline in megaherbivore richness and biomass density during the later phases of the Pleistocene and the Holocene (Ben-Dor and Barkai, 2020). We concluded that the ethnographic quantitative subsistence analogies with the Pleistocene are not viable, due to major differences in megaherbivore availability and related environmental consequences. The only recent groups that were referenced in Lupo and Schmitt (2016) as hunting elephants live in the densest jungles of Central Africa, an extremely unrepresentative environment for hunter-gatherers in the deep past or recent past, especially when it comes to Pleistocene acquisition of elephants that occupied diverse but mostly open environments. Thus, we question the relevance of their analysis with regard to hunter-gatherers occupying non-forested areas. Moreover, according to our analysis of an actualistic case here, the giraffe, the lowest ranking animal in Lupo and Schmitt's analysis, contributed more than 50% of the weight of the Hadza's animal-based diet (see Fig. 12.5). In fact, the lowest-ranking animals in the Lupo and Schmitt analysis are the largest animals (eland, giraffe, elephant), and the highest-ranking are the smallest animals (bush duiker, springhare, steenbok, bat-eared fox). The Hadza seem to behave exactly in opposition to this ranking in that around 90% of their hunting weight originates from the largest animals (giraffe, buffalo, eland, zebra; Fig. 12.5). This trend of large prey dominance in the Hadza meat acquisition is confirmed by Marlowe (2010: fig. 8.7), who also rejects the "hunting as costly signaling" hypothesis based on the data he collected (Marlowe, 2010: pp. 215–216). The last point in this regard has to do with the view that recent hunter-gatherers of the Congo basin are purposefully making efforts to remain egalitarian and keep personal autonomy, even though elephant hunting might be used to gain personal benefits that might undergo the social cohesion of the group (Lewis, this volume; Yasuoka, this volume). This view of the Baka Pygmies elephant hunters of Central Africa is in strict opposition with the costly signaling argument suggested by Lupo and Schmitt (2016). It presents a socio-cultural mechanism of making use of the dietary benefits of hunting and consuming elephants while maintaining an egalitarian way of life (Yasuoka, this volume).

RELATIVE BIOMASS OF VERY LARGE HERBIVORES | The late Quaternary extinction (Barnosky et al., 2004) and the further extinction of large species during the Holocene (Braje and Erlandson, 2013) make present biomass density distribution studies inapplicable to Palaeolithic ecological analogies (Faith et al., 2019).

Still, even present studies of large herbivores' density (reviewed in Silva and Downing, 1995) find that the largest herbivore species sustain higher densities than predicted by general power-function relationships between density and body mass. Silva and Downing (1995: pp. 711–712) speculate that the relative higher densities of large herbivores are due to lower rates of predation, ability to exploit low-quality resources and plant cell walls, and domination of inter-specific aggression. They conclude, "…thus, the largest mammals may be able to extract more energy from the environment, which permits them to sustain higher densities than simple allometry predicts".

Elephants still dominate the biomass of herbivores in several African nature reserves forming up to 80–89% of the herbivores' biomass (Leuthold and Leuthold, 1976: tab. 4; Milligan et al., 1982; White, 1994; Valeix et al., 2007). In some game-reserves, where elephants and other megaherbivores are protected from predation by humans, they are so "embarrassingly successful" as one researcher (Owen-Smith, 1988: p. 2) put it, that there is often a need to reduce their population by culling in order to avoid vegetal and faunal changes that are detrimental to the existence of other species. This phenomenon naturally also raises the possibility of a role for humans in top-down control of megaherbivores' populations in the past.

Reconstructing the biomass density of herbivores in Africa one thousand years ago, Hempson et al. (2015: p. 1056) estimate the "nonruminants"

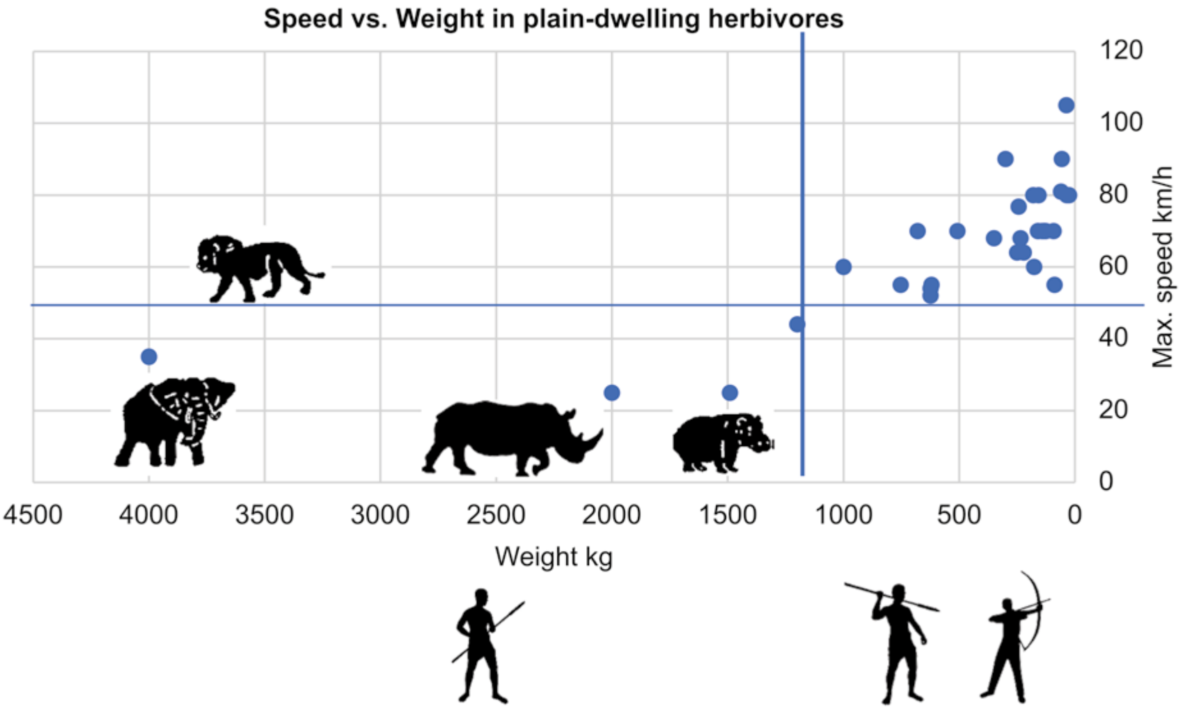

Figure 12.1: Speed vs. weight in plain-dwelling herbivores.

group, which contains mainly megaherbivores, to have had a biomass density of 37 to 10,646 kg/km². "Water-dependent grazers," the second densest group, which includes a larger number of medium-sized animals such as wildebeest, achieve only some one-sixth of the biomass density of the "non-ruminants" group (0–1553 kg/km²). They predict that elephants, in particular, provided an exceptional amount of herbivore biomass. Elephants were particularly widespread in different ecological regions of Africa, possibly due to their ability to feed on low-quality forage and a broader variety of stages of vegetation, which improves resource partitioning. Hempson et al. (2015: p. 1056) predict that one thousand years ago, "elephants dominate African herbivore biomass, often having biomasses equivalent to those of all other [herbivores] species combined".

It is well accepted that the productivity of carnivores is a function of the abundance of herbivores (Leonard and Robertson, 1997). Therefore, it only makes economic sense that a predator capable of hunting megaherbivores, which were probably mainly humans (Agam and Barkai, 2018), will spend a significant amount of his energetic budget exploiting this high biomass density. The dominant share of large herbivores of the total potential prey biomass also has economic implications in that, relative to their biomass, large herbivores are encountered in higher frequencies. Additionally, because of their size, megaherbivores are conspicuous in the landscape and leave large traces of their presence in the form of spoors and excrements. They are also water-dependent (Hempson et al., 2015), so they can be expected to periodically frequent known water sources. In summary, megaherbivores are found in great numbers and are relatively easy to trace and locate. We, however, do not claim that megaherbivores were the dominant herbivores always and everywhere. Throughout the Pleistocene, there are regions and periods with evidence for the varying presence of megaherbivores. We do claim, however, that as megaherbivores represent an unprecedented amount of fat and protein, it was always the preferred prey whenever available. When unavailable, humans had to invest more effort in

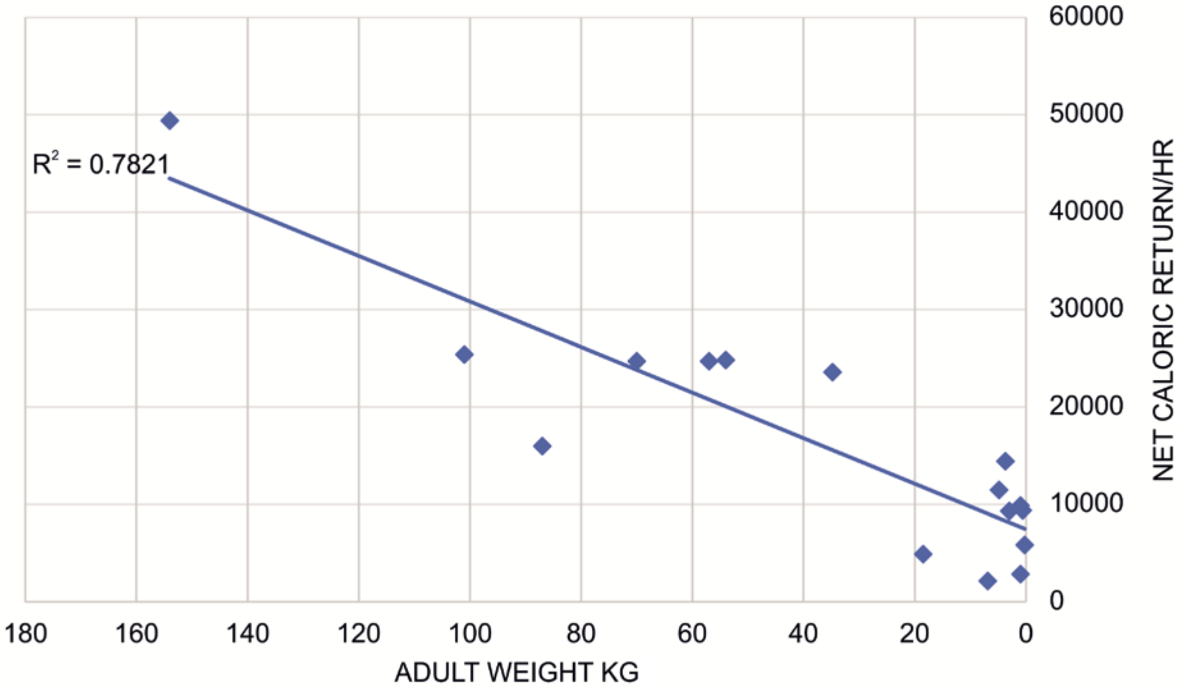

Figure 12.2: Net caloric return/hour by animal weight (Kelly, 2013: tabs. 3–4).

supplying the necessary caloric intake by pursuing smaller game and other resources.

NOT ESCAPING – EASIER TRACKING AND LESS COMPLEX HUNTING TOOLS | Figure 12.1 draws the maximum speed of plain-dwelling herbivores in relation to their size. As shown below, megaherbivores —namely elephants, rhinos, and hippos— do not rely on escape as a predator protection strategy, as evident by their low maximum speed compared to that of a lion (Hirt et al., 2017: appendix). Unlike ungulates, megaherbivores lack specific predation risk alarm signals (Owen-Smith, 1988: p. 132). Presently, when humans approach, they tend to stand still and may flee or charge when humans get closer (Owen-Smith, 1988: pp. 127–128). This behavior has several implications that make their acquisition by humans relatively energetically profitable and technologically less complex than hunting smaller, fleeing prey, though arguably requiring great personal courage and associated with increased personal risk.

The chart depicts plain-dwelling herbivores' maximum speed as a function of their weight. It also shows (based on Churchill, 1993) that more complex technologies are used for the acquisition of smaller and faster game, namely thrusting spear for non-escaping megaherbivores, throwing spears (with stone tips) for medium size-medium weight animals, and bow and arrow for smaller and faster herbivores.

The smaller and faster the animal is, the more complex the technology that is used in its acquisition (Churchill, 1993). Generally, fast escaping animals are hunted with projectile weapons. In contrast, there are quite a few methods of hunting elephants that require little technological sophistication. Most of the hunting methods of megaherbivores aim at limiting the mobility of the prey, for example, by digging a pit or driving it to a mud trap, at which time dispatching requires only a wooden thrusting spear (Churchill, 1993; Agam and Barkai, 2018). Both the easier locating and tracking of the megaherbivores and the relatively less complicated tools that are used presumably have bioenergetic profitability implications to their acquisition.

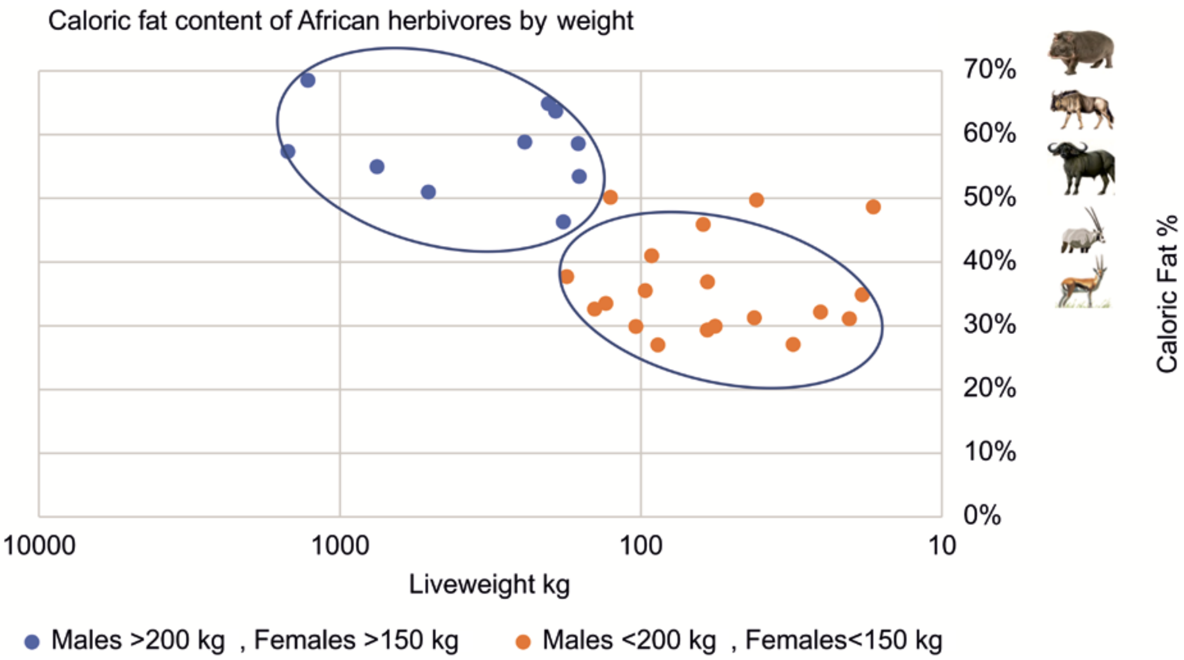

Figure 12.3: The caloric fat content of African herbivores by weight, based on Ledger (1968).

LARGER ANIMALS PROVIDE HIGHER ENERGETIC RETURN | Ethnographic data (Kelly, 2013: tab. 3-4) show that large animals offer higher net energetic returns (Fig. 12.2). Although there are no data for megaherbivores, as these large animals were mostly unavailable for recent hunter-gatherers, the association between size and net energetic return is quite robust.

Ethnographic research shows that large animals rank higher than smaller animals because they provide higher energetic returns (Ugan, 2005: tab. 1; Stiner and Kuhn, 2009: tab. 11.1; Broughton et al., 2011: tab. 1). According to the data in Kelly (2013: tabs. 3–4), medium-sized animals provide a net caloric return of some 25–50,000 calories/hour. In comparison, small animals provide one-fifth to one-half of the net caloric return. Plant food returns are similar to those of very small animals. Seeds, the most nutritious plant food, return 191–13,437 kcal/hr, berries 250–4,018 kcal/hr, and tubers 267–6,252 kcal/hr. Following classic optimal foraging theory (see review in Lupo, 2007), we argue that striving to optimize energetic return, humans will prefer the acquisition of animals, and especially large animals, over plants. Of course, local environmental conditions such as mass extinctions of large herbivores, and seasonal and local abundance of particular plants, may create occasions where plants dominate the diet. However, we have argued that these types of situations had a higher likelihood of occurring relatively recently at the end of the Pleistocene and during the Holocene in areas where the vegetal to faunal biomass ratio had changed dramatically after large herbivores extinctions (Ben-Dor and Barkai, 2020; Ben-Dor et al., in review).

In summary, we believe that bioenergetic considerations weigh heavily in favor of the importance of large herbivores to the human economy during the Pleistocene.

LARGER PREY CONTAINS HIGHER BODY FAT | We hypothesized that dietary animal fat played a crucial role in human survival during the Pleistocene (Ben-Dor et al., 2011, 2016; Ben-Dor, 2018: chapter 7). Protein consumption in humans is limited to around 35–50% of the daily calories, due to the limited ability of the liver and kidney to remove larger quantities of the toxic nitrogen by-product of their metabolism (Speth, 1989). This limitation means that 50–65% of the calories should come from fat or carbohydrates. Elephants contain enormous amounts of fat, about one million calories in the fat of a single mammoth (Guil-Guerrero et al., 2018), and most probably an even higher number of fat calories in the much larger Pleistocene elephants (Ben-Dor et al. 2011). More calories can be gained by accessing the proboscideans' bone marrow (Boschian et al., 2019). Pitts and Bullard (1967) were the first to find that larger mammals contain relatively more fat than smaller animals. An analysis of a dataset of nineteen African herbivore species (Ledger, 1968) confirmed this phenomenon (Ben-Dor et al., 2011) (see Fig. 12.3 and data in Ben-Dor, 2020).

In the Ledger (1968) dataset, male herbivores weighing over 200 kg and female herbivores weighing over 150 kg contain, on average, 44% more body fat, relative to body weight, than smaller animals.

Equally important, since humans mostly occupied seasonal environments, large herbivores maintain a high level of fat during periods of low forage (Lindstedt and Boyce, 1985), probably due to their ability to exploit low-quality forage and lower metabolic rate to body size ratio (Owen-Smith, 2002: p. 88). Since periods of low availability of forage are usually also periods of low plant food availability for humans, large herbivores' fat availability at these periods may become even more critical to humans' survival (Tanner, this volume). Recently, delayed consumption of marrow in the form of preserved fallow deer's bones was identified at Qesem Cave (420 to 200 ka), likely highlighting the criticality of preserving fat for dry seasons (Blasco et al., 2019).

The criticality of the availability of fat, and, consequently, that of large prey, is a function of the relative availability of plants and the relative energetic costs of their exploitation. A multidisciplinary reconstruction of the human trophic level during the Pleistocene (Ben-Dor, 2018: chapter 5.5; Ben-Dor et al., in review) found that humans were highly carnivorous during most of the Pleistocene, declining in trophic level towards the end of the Pleistocene, hand in hand with the late Quaternary megafauna extinction and the concomitant increase in relative vegetation density (Johnson, 2009; Bakker et al., 2016; Faith et al., 2019). Ethnographic reports of low trophic levels in groups like the Hadza of Tanzania and the Ju/'hoansi (!Kung) that are sometimes used to support low trophic level during the Pleistocene were shown to be better analogies to the very end of the Pleistocene, representing adaptations to prey-size declines (Ben-Dor, 2018: chapter 5.3; Ben-Dor and Barkai, 2020). There is insufficient space here to describe the 27 pieces of evidence that the Ben-Dor (2018) and the Ben-Dor et al. (in review) reconstruction of the human trophic level includes, but a short review may be in order. The majority of the evidence (18 items) come from human biology and include genetic, metabolic, and morphological adaptations to a high trophic level that are unique to humans. In some cases, like the high acidity of the human stomach (Beasley et al., 2015), the adipocytes morphology (Pond and Mattacks, 1985), the short weaning period (Psouni et al., 2012), the authors themselves classified humans among carnivores. Genetic information provided signs for adaptation to a higher plant consumption at the end of the Pleistocene. Most of the archaeological evidence (8 items) also supported a high trophic level, leading with stable isotopes data, and fat-oriented large and prime adult prey selection, and exploitation of bone fat at great energetic expense. Other archaeological items like the pattern of stone tools prevalence also pointed to increased plant food utilization towards the end of the Pleistocene. Finally, palaeontological evidence of the type we cite in this paper and analogies with the zoological record regarding carnivores also support carnivorous trophic level during the Pleistocene. Of note, in connection with the subject of this paper, is the fact that all carnivores that acquire large prey are hypercarnivores, obtaining most of their calories from animals (Wroe et al., 2005; Van Valkenburgh et al., 2016).

Species	**Common name**	**Number**	**MNI**	**MAU**	**Average weight (kg)**	**Reference**
Giraffa camelopardalis	giraffe	11	8	39.6	1010	3
Syncerus caffer	buffalo	2	2	19.8	753	1
Taurotragus oryx	eland	2	2	13.0	508	1
Equus burchelli	zebra	15	14	168.7	235	2
Connochaetes taurinus	wildebeest	3	3	26.8	181	1
Alcelaphus buselaphus	hartebeest	2	2	24.0	135	1
Phacochoerus aethiopicus	warthog	6	6	83.6	74	1
Aepyceros melampus	impala	19	19	198.0	50	1
Papio cynocephalus	baboon	1	1	15.0	19	3
Total		61	57	588.5		

Table 12.1: The Hadza sample - Basic data. References for weights. 1, Ledger (1968); 2, Hirt et al. (2017); 3, Skinner and Chimimba (2005: pp. 616–620).

12.3 A METHOD TO CORRECT THE UNDER-REPRESENTATION OF LARGE ANIMALS IN PALAEOLITHIC ARCHAEOLOGICAL ASSEMBLAGES

In an attempt to measure and test ways to correct the potential under-representation of large animals in the zooarchaeological faunal analysis, we analyzed an actualistic ethnographic case study. In this case study, the true quantities of the acquired animals are known, thus enabling a comparison between the various abundance indexes. The common abundance indexes are based on either Minimum Number of Individuals (MNI (species) divided by MNI (total)) or Number of Identified Specimens (NISP (species) divided by NISP (total)) (Lyman, 2018). Neither indexes, however, take into account a possible transport bias of larger animals' heavier bones and probably an even higher bias in the transportation of megaherbivores' bones. Moreover, the weight and caloric content of the different prey animals is not accounted for. For example, in three out of three elephant kills and butchering sites of the Efe in the Ituri forest, observed by Fisher Jr (2001), the entire group moved to temporary camp adjacent to the kill site, and no bones were carried beyond the temporary camp, while large quantities of fat and meat stripped from the bones were transported elsewhere. Total omissions and reduced transport of large animals are bound to bias the indexes to overestimate the abundance of small animals and underestimate the abundance of large animals in the acquired faunal assemblages.

In 1986, two research groups measured multiple variables that were associated with the Hadza's hunting of large prey. O'Connell et al. (1988) initially analyzed 49 cases and later (O'Connell et al., 1990) reanalyzed these cases, plus five additional ones, to a total of 54 cases. Bunn et al. (1988) analyzed 29 additional cases. The purpose of their analysis was primarily to draw analogies that will aid in differentiating kill and butchering sites from central place type archaeological sites. Later, Monahan (1998) combined both groups' data in a reanalysis of his own. The increase in sample size comes at the cost of combining results from two separate geographical backgrounds. However, we feel that since the same group is studied at the same time (1985–6) in the group's territory, the averaging effect of combining the group may even be advantageous rather than deleterious. We used the data from Monahan (1998: tab. 2). The table lists 61 animals for which the meat and skeletal elements were transported away from the Hadza kill and butchery sites to a central place (camp). Immature animals and scavenged animals that were partially exploited were eliminated from Mo-

		True				Assemblage			
Animal	Average weight (kg)	Number	%Number	%Biomass		%MNI	%MAU	%Biomass (MNI)	%Biomass (MAU)
giraffe	1010	11	18 %	57 %		14 %	7 %	50 %	32 %
buffalo	753	2	3 %	8 %		4 %	3 %	9 %	12 %
eland	508	2	3 %	5 %		4 %	2 %	6 %	5 %
zebra	235	15	25 %	18 %		25 %	29 %	20 %	32 %
wildebeest	181	3	5 %	3 %		5 %	5 %	3 %	4 %
hartebeest	135	2	3 %	1 %		4 %	4 %	2 %	3 %
warthog	74	6	10 %	2 %		11 %	14 %	3 %	5 %
impala	50	19	31 %	5 %		33 %	34 %	6 %	8 %
baboon	19	1	2 %	0 %		2 %	3 %	0 %	0 %

Table 12.2: The Hadza sample - Comparison of true, MNI and MAU abundance indexes.

nahan's data. Bunn's group used MNE (Minimum Number of Elements), and O'Connell's group used MAU (Minimum Number of Units) to report the skeletal elements that were transported to the base camp. We transformed Bunn's group's MNE to MAU based on data regarding the number of elements in animals at the bottom of Monahan's table 2. A summary of the data appears in Table 12.1.

Although other researchers use an estimate of the consumable meat to calculate the dietary contribution (White, 1953), we used the total liveweight since our main aim here is to correct a bias in transporting body parts, including bones, and there is no evidence that the consumable meat weight is a better predictor of this bias. Also, according to our hypothesis, large animals are preferred mainly because of the high total weight and size that confers various advantages in locating and acquiring them.

In Table 12.2, we compared the widely used MNI- and NISP- (MAU- in our case) based abundance indexes (Lyman, 2018) to indexes that account for the animal weight (relative MNI or NISP multiplied by animal weight). The indexes were compared to the "true value". The true value was based on the relative number of each animal multiplied by its weight. For example, the true potentially consumable biomass contribution of the giraffe is 57% of the total weight. Eleven giraffes were obtained out of a total of 61 animals. Since each giraffe weigh 1010 kg, their weight contribution was 11 × 1010 = 11,110 kg. The total weight of the assemblage was 19,383 kg, hence 11,110/19,383 = 0.57 = 57%.

The table demonstrates that MNI is constantly closer to the true abundance than MAU (NISP), especially of the larger and smaller species where the relative under- and over-representation of MAU-based indexes are high. For example, giraffes form 18% of the total true number of animals and 14% of the total MNI, while they constitute only 7% of the total MAUs. Since the largest animals in this sample contain several times the weight of smaller animals, the use of MNI is critical to the correction of the relative biomass bias.

Regarding biomass, it can be seen from Table 12.2 that there is a major underestimation of the large animals' potentially consumable biomass share if the regular MNI or NISP abundance indexes are used. This bias stems mainly from the fact that no bones were brought back to camp from three out of the eleven giraffes consumed, so they were not counted in the MNI. As we saw (Fisher Jr, 2001), when larger animals such as elephants are acquired, the consumption of the meat and fat will sometimes take place at the kill site, so the number of times that zero bones were transported

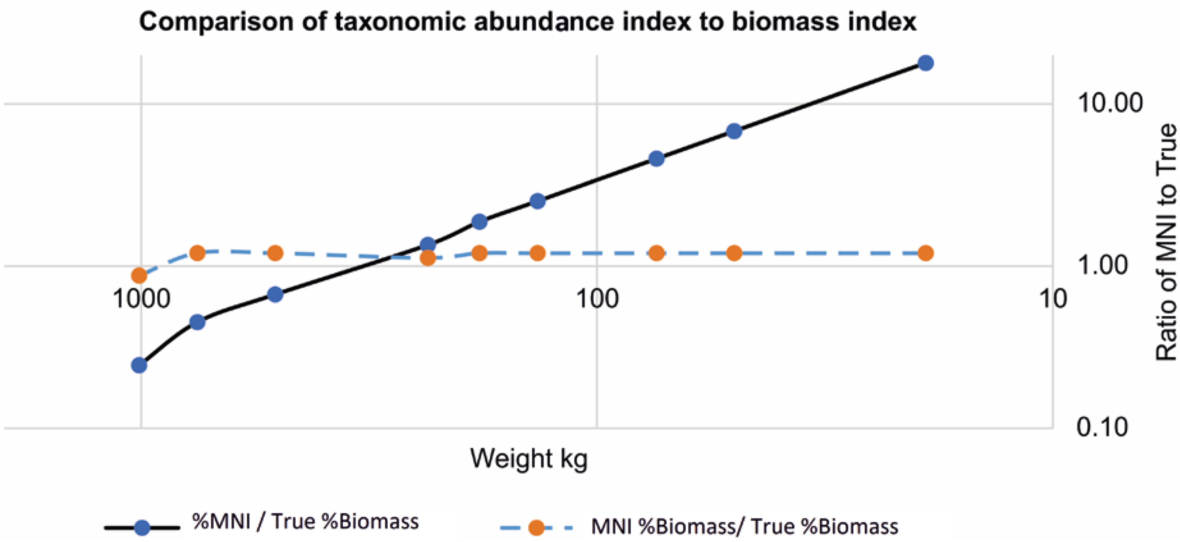

Figure 12.4: Comparison of taxonomic abundance index to weight-adjusted index.

to the central place will be high and so will the bias. The bias is also very apparent in small animals. The 19-impala contributed only 5% to the true potential consumable biomass while their MNI abundance index was 33%.

As expected (Lyman, 2018), the NISP (MAU) index performed even worse than the MNI-based index when it came to predicting relative dietary importance (biomass). In Table 12.2, for giraffes, the true biomass index (57%) is only 14% higher than the MNI biomass index (50%), while it is 78% higher than the NISP biomass index (32%). These results make reliance on NISP data a distant second-best to MNI. At least according to the Hadza sample, the potential for substantial remaining underestimation of the relative biomass of large animals should be taken into account when using NISP data.

A marked improvement took place when the MNI abundance index was multiplied by the animal weight. The "Weight adjusted MNI index" (the "MNI biomass index") predicts a 50% share for the giraffe compared to a true value of 57%. This stems from the fact that the initial bias in transportation is a function of the weight of the animal. As can be seen both in Bunn et al. (1988) and O'Connell et al. (1988) data, the relative number of elements that are transported is affected by the weight of the animal and the distance of the kill site from base camp, which is also, stochastically, a function of the weight of the animals.

In Figure 12.4, we show the relative predictive strength, compared to the true values, of the commonly used MNI abundance index and the one proposed here that standardizes the MNI abundance index by the animal weight (MNI biomass index). We do that by dividing the MNI abundance index and the MNI-based biomass index values by the true value for each species. For example, the MNI abundance index for impala is 33%, and the MNI biomass index is 6%, whereas the true biomass contribution of the impala is 5%. We calculate 6.6 times (33% divided by 5%) overestimation relative to the MNI abundance index, compared in the dotted line to 1.2 times (6% divided by 5%) overestimation in the MNI biomass index compared to the true value. The straight log/log line of the relation between the MNI-based taxonomic index (%MNI) and the true values indicates a strong correlation between animal weight and bone transportation. The slope changes at the giraffe, which may point to there being a threshold animal size in which the trans-

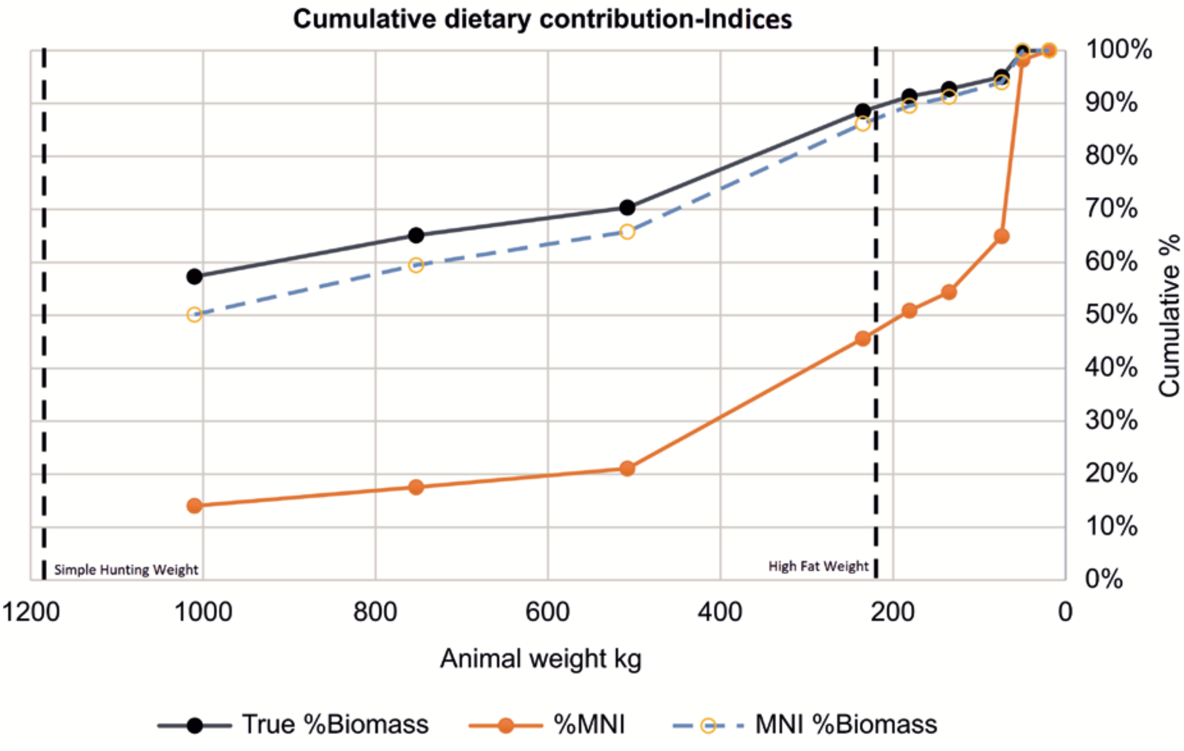

Figure 12.5: Cumulative potentially consumable biomass contribution by weight. (the dotted vertical lines denote weights of animals that are relatively less complex to hunt (See section „Not escaping – Easier tracking and less complex hunting tools") and animals with relatively high fat content (See section „Larger prey contains higher body fat").

port of bones to the central place is diminished at a faster rate. In the giraffe, the largest animal, the MNI index underestimation drops from 76% in the MNI abundance index to 13% in the MNI biomass index. Since Y = 1 in the chart is the true value (%MNI*Weight = %Number*Weight), the flat line close to 1, after the addition of weight standardization to the straight MNI abundance index, shows that the multiplication by weight leads to a significant improvement of the prediction of the relative dietary importance of the various species.

12.3.1 CUMULATIVE PRESENTATION OF THE BIOMASS ABUNDANCE INDEX

Having a hypothesis regarding the dietary importance of large prey animals and an index that arguably provides better predictions of their relative dietary importance, we can now compose a model that will allow us to infer the significance of prey availability on human behaviors, based on Palaeolithic faunal assemblages. Firstly, we would like to know what percentage of the diet was supplied by animals that could be obtained with relatively less complex technological means. Based on the maximum speed chart (Fig. 12.1), these are animals that weigh over 1200 kg and that do not tend to escape. The second point of interest is what percentage was supplied by animals with relatively high-fat content, which, according to our calculations, weigh over approximately 150 kg for females and approximately 200 kg for males (Fig. 12.3). We would also like to know what portion of high net return animals contributed to the diet, assuming, as per section "Larger animals provide higher energetic return", that larger animals provide a higher return than small animals. For that purpose, we calculate the cumulative values of the biomass index, beginning with the largest animal (Fig. 12.5).

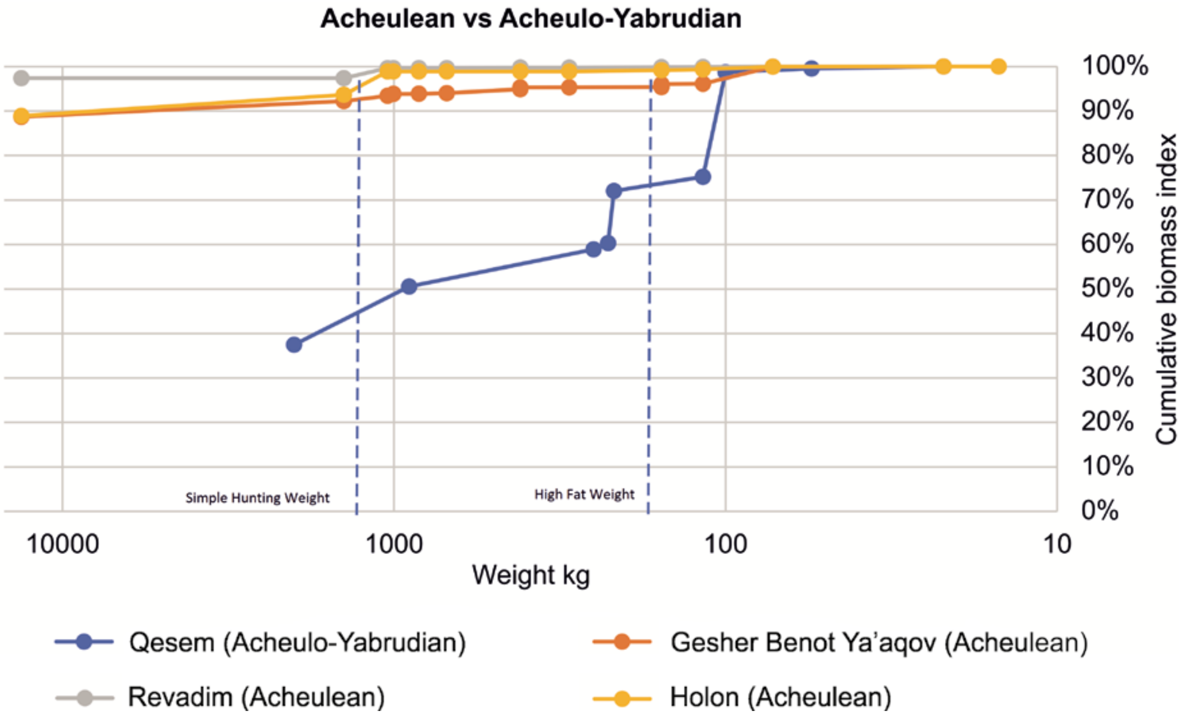

Figure 12.6: The Levant - Acheulean sites (Gesher Benot Ya'aqov, Revadim, Holon) vs. Acheulo-Yabrudian site (Qesem Cave). The dotted vertical lines denote weights of animals that are relatively less complex to hunt (See section „Not escaping – Easier tracking and less complex hunting tools") and animals with relatively high fat content (See section „Larger prey contains higher body fat").

Assuming that the data includes a representative sample of the Hadza animal-based diet, it can be concluded that the true contribution of animals that do not escape (heavier than 1200 kg) to the animal portion of the diet is nil (Section "Not escaping – Easier tracking and less complex hunting tools"). The giraffe's maximum speed is 60 km/h (Hirt et al., 2017: appendix), faster than a lion, so it is built to escape. We can thus predict that the Hadza had to use projectile technology suitable for the acquisition of escaping prey. Since giraffes form over 50% of the potentially consumable biomass, we can conclude that the Hadza would have had a hard time obtaining a significant quantity of meat without projectile technology. With the addition of animals that weigh close to 200 kg, the Hadza reach 90% of the animal portion of the diet. We can thus determine that most of the animal portion of their diet is obtained from animals that provide a relatively high net caloric return (Section "Larger animals provide higher energetic return") and contain a relatively high level of fat (Section "Larger prey contains higher body fat ").

12.4 APPLICATIONS OF THE MODEL

12.4.1 SOUTHERN LEVANT - COMPARING ACHEULEAN TO ACHEULO-YABRUDIAN SITES

There is a clear difference in the composition of prey by size between the three Lower Palaeolithic Acheulean sites (Gesher Benot Ya'aqov, Holon and Revadim) and the terminal Lower Palaeolithic Acheulo-Yabrudian Qesem Cave (Fig. 12.6). In the Acheulean, nearly 100% of the animal-based diet came from megaherbivores, specifically from *Palaeoloxodon antiquus*, that presumably do not escape and supply a high level of fat. However, in the Acheulo-Yabrudian, only 39% of the animal-based diet came from

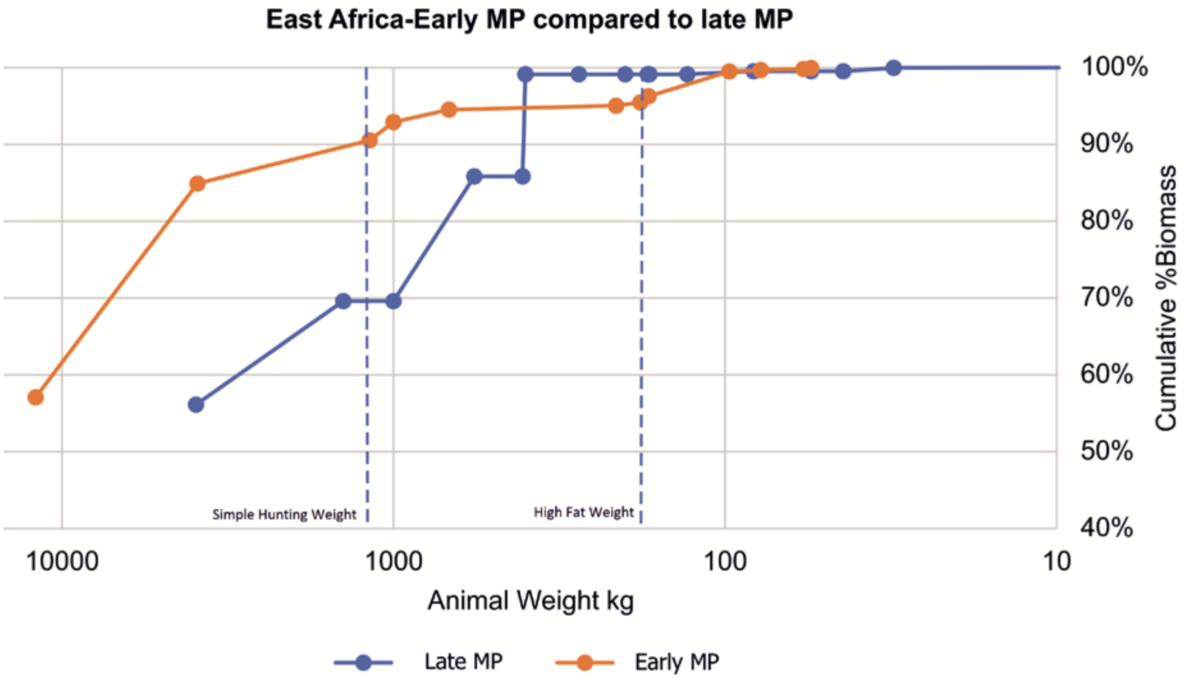

Figure 12.7: East Africa - early Middle Pleistocene vs. late Middle Pleistocene. The dotted vertical lines denote weights of animals that are relatively less complex to hunt (See section: „Not escaping – Easier tracking and less complex hunting tools") and animals with relatively high fat content (See section: „Larger prey contains higher body fat").

animals heavier than 1200 kg that do not escape (rhino, in this case). Moreover, only 70% of the cumulative weight of the animals from Qesem Cave came from high fat-containing animals (above ~200 kg). The 30% contribution of small animals, specifically fallow deer (23%), to the diet is substantial. The need to efficiently hunt a much larger portion (61%) of escaping animals and process a high number of the smaller animals, compared to the Acheulean, may explain the dramatic cultural differences and possibly physiological differences between the Acheulean and the Acheulo-Yabrudian humans and culture (Ben-Dor et al., 2011; Barkai and Gopher, 2013; Barkai et al., 2017). One caveat in this comparison is that the Acheulean sites are open-air sites, and the Acheulo-Yabrudian site is a cave site that may contain smaller-sized animals on average, regardless of culture or region (Smith et al., 2019b). Also, both periods are compared based on NISP data. As we saw in the Hadza case, it is probable that the use of NISP results in a lower correction of the biomass index bias, which in this case would be more significant in the case of Qesem Cave, extending the difference between the two periods beyond the true value.

12.4.2 EAST AFRICA - EARLY MIDDLE PLEISTOCENE COMPARED TO LATE MIDDLE PLEISTOCENE

The early Middle Pleistocene (MP) is represented in the data by Olorgesailie Member 10 and the late MP by Olorgesailie BOK 1E, 2 and 4, and by Omo Kibish 1 (data in Ben-Dor, 2020, extracted from Smith et al., 2019b), all by MNI. In the late MP, 70% of the diet was obtained from non-escaping animals that are relatively less complex to locate and hunt, compared to 93% in the early MP. Here, we should note that in the early MP, *Palaeoloxodon recki* was the elephant species in the assemblage, while it was the smaller (and possibly less naive?) *Loxodonta africana* in the late MP.

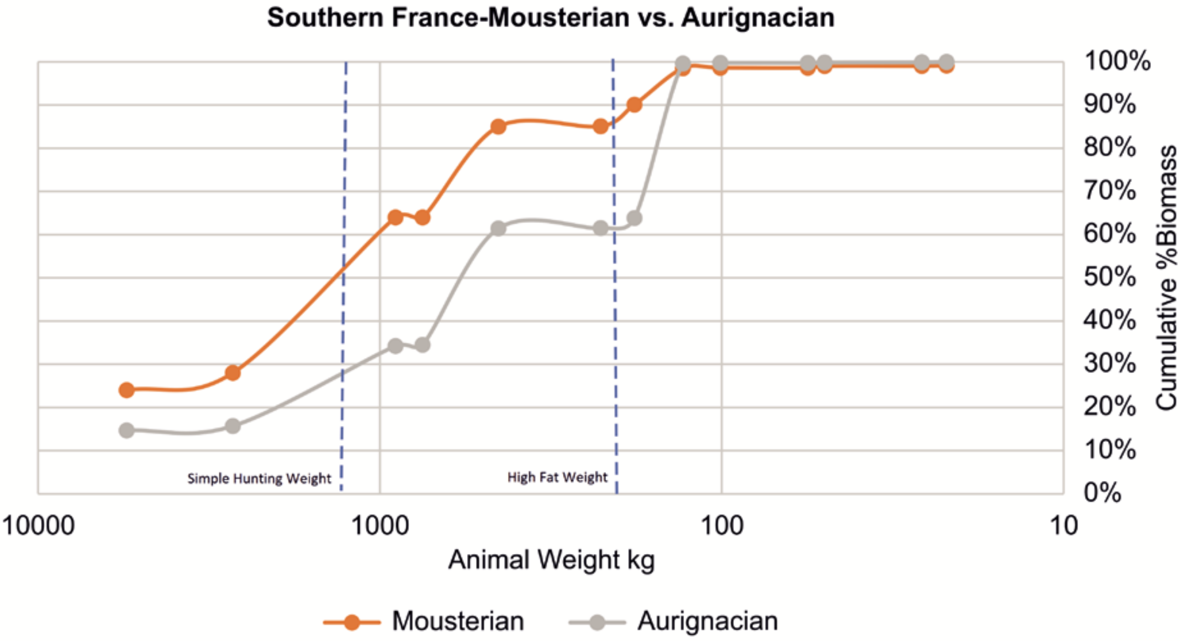

Figure 12.8: Southern France - The Mousterian vs. the Aurignacian. The dotted vertical lines denote weights of animals that are relatively less complex to hunt (See section: „Not escaping – Easier tracking and less complex hunting tools") and animals with relatively high fat content (See section: „Larger prey contains higher body fat").

There is a cultural change with the appearance of the Middle Stone Age in East Africa at the late MP. Potts et al. (2018) and others (Faith et al., 2012; Owen et al., 2018) noticed a general decline in herbivores' sizes with a faunal turnover at the end of the early MP, which is reflected in the right shift of the curves between the early MP and late MP in Figure 12.7. It is possible that the need to hunt escaping animals and a new elephant species was part of the trigger for the cultural change from the Acheulean to the Middle Stone Age, as it has arguably been the case in the Levant's transition from the Acheulean to the Acheulo-Yabrudian. In both, the early and late MP, the high-fat line at 200 kg shows that close to 100% of the weight of the prey were of high fat content.

12.4.3 SOUTHERN FRANCE – THE MOUSTERIAN COMPARED TO THE AURIGNACIAN

Analysis of a database that includes the NISP record of 169 Middle Palaeolithic Mousterian layers and 41 Upper Palaeolithic Aurignacian layers (Grayson and Delpech, 2002) shows (Fig. 12.8) that on both counts, dealing with non-escaping animals (>1200 kg) and obtaining animals with a high-fat content (>200 kg), the Anatomically Modern Humans (AMH) of the Aurignacian had a harder time. Hunting non-escaping animals only provided some 15% of their animal-based diet, compared to some 30% for the Neanderthals of the Mousterian. In terms of obtaining animals with high fat content, some 60% of the Aurignacian hunted biomass was obtained from animals with higher levels of body fat, while Neanderthals obtained some 90% of their animal-based diet from high fat containing animals (>200 kg). These differences can shed light on possible physiological and cultural adaptations that allowed modern humans to succeed in handling both these handicaps. It can be hypothesized that lighter bodyweight and advanced agility allowed AMH to acquire smaller escaping animals at reduced locomotion costs (Steudel-Numbers and Tilkens, 2004). Use of projectile hunting tools, which are used mainly on smaller prey, is also sometimes mentioned as a differentiating capability, although there are signs that Neanderthals may have also used some projectile tools (Hardy et al., 2013). There are even some scholars who claim that AMH were anatomically adapted to the use of projectile tools (Churchill and Rhodes, 2009).

It should be mentioned that most of the sites in the database are cave sites, and one would expect the bias against the representation of proboscideans to be higher than in open sites (see discussion). Moreover, as discussed, the NISP (rather than MNI) data of this dataset may still leave substantial room for underestimation of large animals biomass contribution.

12.5 DISCUSSION

We hypothesized that the criticality of large prey to humans, coupled with a decline in prey size during the Pleistocene, has led to behavioral and possibly also physiological adaptations that we described here and in the cited papers. Underrecognition of the true relative abundance of large prey animals in archaeological sites may blind us to the importance of large prey animals in general, and to specific trends in large prey prevalence that could drive the hypothesized adaptations. We have described a method to correct some of the underrepresentation of large prey in archaeological sites. However, the method may still leave much room for the underrepresentation of very large prey animals, such as proboscideans, since they may be significantly underrepresented in the MNI and even more so in the NISP. For example, in the Hadza sample (Table 12.1), 27% of the giraffes are not included in the MNI because not a single bone of 3 out of the 11 giraffes was brought to the central place. In contrast, only one smaller animal out of 50 (2%) is not represented in the MNI of the assemblage. It seems that there is a certain bodyweight/distance threshold above which bones become too heavy to transport, or the meat and fat contribution becomes so high for a given group size, that there is less incentive to bring bones to the central place. Alternatively, in the case of large herbivores, bones might be striped of meat and fat at the hunting station and be left there, so no hard evidence for the transport of a huge amount of calories would be represented at the central place. If true for a giraffe, it is undoubtedly true for proboscideans, which weigh about six times more than a giraffe and, in the past, were up to ten times heavier.

12.5.1 UNDERREPRESENTATION OF PROBOSCIDEANS

Theoretically, one can think of a method to account for “missing” individuals that rely on the relative biomass density in a given environment. If we accept that humans prefer large prey, we also have to account for a preference for the acquisition of a higher proportion of large prey, say proboscideans, than their relative biomass density in the environment. To estimate the level of preference, we tried to determine the relationship between the relative natural biomass of giraffes in East Africa and their relative biomass in the Hadza assemblage. We reviewed the East African record of biomass density of six nature reserves (Leuthold and Leuthold, 1976), presenting more than four species from the Hadza sample and calculated an average biomass density of 13% for giraffe in relation to the other animals in the Hadza sample (minimum 2%, maximum 36%) (calculations in Ben-Dor, 2020). Since the biomass density of giraffe in the Hadza sample is 57% (Table 12.2, %biomass), we can infer a strong “preference factor” of (57% divided by 13%) of 4.4 times (maximum 32, minimum 1.6) compared to the relative natural biomass density. So, theoretically, if we can estimate the relative biomass density of proboscideans, as was done by Hempson et al. (2015), and estimate the preference factor for proboscideans, we may be able to estimate the relative acquired proboscidean biomass in the absence of bones. There are many limitations to the applicability of the Hadza sample to actual cases. Firstly, the data from nature reserves may not be representative of the biomass distribution in the

Hadza territory. Also, it is known that the Hadza do not hunt proboscideans despite their occasional presence in their territory (Marlowe, 2010). The considerations of which specific species to hunt may be many and varied. For example, contrary to giraffes, we have calculated the preference factor for the buffalo to be strongly negative at 0.2 (8% of the biomass in Table 12.2 divided by an average of 46% in nature reserves). One potential explanation for not hunting elephants and rarely hunting buffalo can be a reliance of the Hadza on the bow and poisoned arrows in hunting. Bow and arrow may not have the capability of deterring potential charges from elephants and buffalo (Owen-Smith, 1988) and might be relatively inefficient in such a hunt. In contrast, giraffes typically do not charge (Owen-Smith, 1988: p. 126). As we pointed out, hunting of elephants and other large animals is typically performed using other tools/weapons and different methods (Churchill, 1993; Agam and Barkai, 2018). In summary, it seems that a method that uses relative biomass densities to account for missing proboscideans needs more study before it can be applied. However, general considerations regarding the underrepresentation of proboscideans that take into account their relative biomass and an assumption of preference for the acquisition of large prey may still be of value.

For example, the relative natural biomass density method may be helpful in generally assessing the likelihood of the three applications of the assemblage biomass model in section 12.4 regarding proboscideans. We start with the estimate of Hempson et al. (2015) of >50% relative natural biomass of proboscideans among herbivores in Africa a thousand years ago and take as a guide a cautious preference for proboscideans as for the minimum preference factor (1.6) that we found for the giraffe based on the biomass in the African nature reserves. Thus, we would expect the proboscideans to compose >50% times 1.6 = >80% of the relative biomass in the assemblages. The Levant Acheulean sample at close to 90% proboscideans (section 12.4.1) seems to be in line with the natural biomass density method, while the East African late Middle Pleistocene sample at slightly less than 60% (section 12.4.2) seems moderately lower than expected. The analysis of Southern France (Section 12.5.3) points to a possible substantial under-representation of proboscideans at 15–25% of the biomass in both the Mousterian and the Aurignacian, much below 80%.

We emphasize that the lack of localized historical data limits the use of the natural biomass method in predicting past relative acquired biomass predictions. The introduction of the method here is meant only to generate questions and hypotheses and interest in the prediction of natural biomass data of the kind that Hempson et al. (2015) performed.

12.6 CONCLUSIONS

The abundance of fossilized bones in prehistoric archaeological sites shows that the acquisition of animals, including very large animals, was an essential activity of humans. We described several reasons for the critical importance of large herbivores as prey. The question that we tried to answer here was how we could determine the relative importance of large and very large animals in archaeological assemblages. The answer to this question, in general and in particular situations, may have critical implications for understanding human behavior and evolution. We presented arguments for the position that the acquisition of large prey was more energetically efficient and less technically complex than the acquisition of small prey animals. We showed evidence that large animals have relatively higher biomass density in the environment, and, maybe most importantly, pack relatively more fat than smaller animals.

Using an actualistic database, we have presented a case for a need for species biomass adjustment of, preferably, MNI- or else, NISP-based abundance indexes in Palaeolithic assemblages, when the relative economic importance of species is investigated. We have also presented a method for the presentation of biomass abundance results, in a way that will allow estimation of the need for less or more complex hunting tools and technics and the availability of relatively fat animals in order to overcome the limit on protein metabolism. Three demonstrative comparisons of two Palaeolithic faunal assemblages each from different regions and periods were performed using the method. We also made an initial proposal of a method that may be more suitable for the prediction of the relative consumption of proboscideans, where, in many cases, no bones are transported from the kill or butchery sites.

We believe that the importance of this type of analysis will become more apparent as the crucial implications to humans of the massive extinction of large prey animals during the Pleistocene are beginning to come to light.

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13. ISOTOPIC INSIGHTS ON ECOLOGICAL INTERACTIONS BETWEEN HUMANS AND WOOLLY MAMMOTHS DURING THE MIDDLE AND UPPER PALAEOLITHIC IN EUROPE

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ABSTRACT

Carbon and nitrogen isotopic composition of bone collagen in woolly mammoths, coeval herbivores and predators, as well as hominins, allow researchers to quantify the proportion of meat consumed by late Neanderthals and early modern humans in Europe. The proportions of consumed mammoth meat were found to be very high for late Neanderthals in sites from western France and Belgium between 45 and 40 ka, and for early modern humans from Belgium, Czech Republic, Crimea and western Russia, between 40 and 30 ka. A possible contribution of freshwater resources was excluded in Belgium and Crimea using a novel approach based on single compound amino acid nitrogen isotopes and confirmed that mammoth consumption was the source of the high nitrogen isotopic ratio of ancient hominins in these sites. The impact of mammoth hunting on the Late Pleistocene ecosystems could be detected by a shift of isotopic values of horses onto those found for mammoth, suggesting that horses could use part of the ecological niche of mammoth probably due to a decrease of the proboscidean population. Moreover, isotopic tracking of predator diet suggests that the mammoth carcasses left by humans were also exploited by scavengers, such as fox, wolverine and brown bear. Therefore, stable isotopic tracking is a very useful approach to decipher the trophic interaction between hominins and mammoths and their possible ecological consequences.

13.1 INTRODUCTION

The discovery that prehistoric humans and mammoths lived at the same time was a shock for early

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scholars during the 19th century (Cohen, 1994). If artifacts made of mammoth bones or ivory could have been made using raw material from long dead ones, the engravings of mammoths with anatomical details clearly demonstrated the contemporaneity of both taxa as this could be done only by observing living mammoths. However, the coexistence of prehistoric humans and mammoths does not tell us how they interacted ecologically.

Extant elephants, the closest relatives of woolly mammoths and with a similar size, are immune from predatory pressure, except from human hunters. Today the hunting of elephants with guns takes dramatic proportions to the point of threatening the species to become extinct (e.g., Douglas-Hamilton, 1987; Thouless et al., 2016). However, recent hunter-gatherer without modern weapons can also kill elephants (see review in Agam and Barkai 2018; Ichikawa, this volume; Lewis, this volume). Did prehistoric people also do it? Archaeological evidence demonstrates that ancient elephants and mammoths were being butchered already hundreds of thousand years ago, implying that prehistoric people must have consumed elephant and mammoth meat for a long time. Active hunting is more difficult to demonstrate, but some convincing evidence has been described (e.g., Nikolskiy and Pitulko, 2013; Metcalfe, 2017; Sinitsyn et al., 2019; Wojtal et al., 2019). Even in such cases, the amount of mammoth meat consumption by humans is very difficult to evaluate. Still, active hunting is a crucial topic, because the intensity of mammoth exploitation has an impact on the demography and ecology of the hunted populations, or even the whole species, and could have contributed to their extinction.

In this contribution, we review how using stable isotope palaeoecological tracking can contribute to quantifying mammoth meat consumption by late Neanderthals and early Upper Palaeolithic modern humans in Europe. Moreover, we evaluate the possible ecological impact of mammoth hunting by humans.

13.2 PRINCIPLE OF ISOTOPIC TRACKING OF PREY CONSUMPTION AND APPLICATION TO MAMMOTH AND OTHER EXTINCT PROBOSCIDEANS

Animals obtain the carbon and nitrogen atoms needed for their metabolism from their food. These two major chemical elements of life can be found under two forms with slightly different atomic weights, called isotopes. The relative abundance of the isotopes of a given element varies slightly in different food categories, due to small differences in the speed of chemical reaction and the strength of chemical bonds between the isotopes of a given element. The differences between isotopic abundances in natural products are extremely small and therefore, in order to be measured accurately, they need to be compared to those of an international standard, under the conventional notation delta as follows:

$\delta^{13}C = [((^{13}C/^{12}C_{sample})/(^{13}C/^{12}C_{standard})) - 1] \times 1000$, where standard is V-PDB;
$\delta^{15}N = [((^{15}N\ /^{14}N_{sample})/\ (^{15}N\ /^{14}N_{standard})) - 1] \times 1000$, where standard is AIR.

Typically, the tissues of an animal are enriched in the heavy isotope of carbon and nitrogen, and their $\delta^{13}C$ and $\delta^{15}N$ values are higher than those of their average food. As we are dealing with meat eaters and comparing the bone collagen of predators and their potential prey, we will consider only the differences between collagen isotopic abundances of the prey and of the predator in the rest of this chapter. Using the results of feeding experiments on captive animals and measurements performed on animals from field studies, the difference between the $\delta^{13}C$ and the $\delta^{15}N$ values of a predator compared to those of its average prey is +1.1 ± 0.2 ‰ and +3.8 ± 1.1 ‰ for $\delta^{13}C$ and $\delta^{15}N$, respectively (Bocherens and Drucker, 2003; Drucker et al., 2017; Krajcarz et al., 2018). In large mammals, bone collagen averages the isotopic composition of several years of life of an individual (e.g., Hedges et al., 2007). Therefore, predators feeding preferentially on prey with dis-

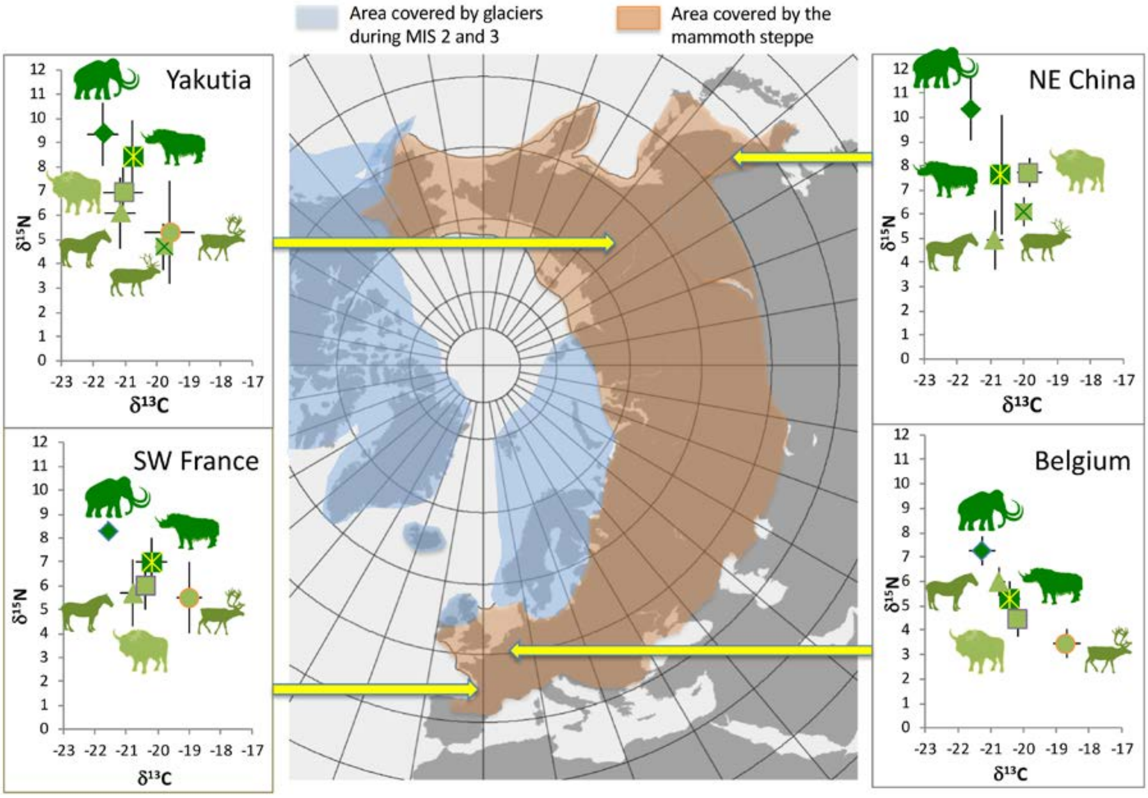

Figure 13.1: Examples of carbon and nitrogen isotopic composition of the main large herbivores coexisting with mammoths in Eurasia. Data for NE China are from Ma et al. (2017); for Yakutia from Bocherens et al. (1996), Iacumin et al. (2010), Szpak et al. (2010), Kirillova et al. (2015), Arppe et al. (2019); for Belgium from Bocherens et al. (2011); for SW France from Bocherens et al. (2005). Map modified from Jürgensen et al. (2017).

tinct $\delta^{13}C$ and $\delta^{15}N$ values due to their specific habitat and diet composition will also exhibit isotopic differences, and it will be possible to evaluate the relative contribution of different potential prey in their average diet in modern (e.g., Yeakel et al. 2009, 2013; Adams et al., 2010; Dalerum et al., 2012) and ancient contexts (e.g., Bocherens et al., 2005; Bocherens, 2015). With the use of stable isotope mixing models it is possible to evaluate quantitatively the proportions of different categories of consumed proteins (i.e., prey), if they present different isotopic abundances. In contexts with a reasonably complete knowledge of the available prey and their isotopic values, using such approaches yields results that allow the comparison of different predators with human hunter-gatherers, and prehistoric sites of different geographic and chronological settings.

In the context of Late Pleistocene glacial terrestrial ecosystems in Eurasia, the isotopic signatures of mammoth bone are distinctive compared to those of other large herbivores and potential prey of prehistoric humans (Bocherens et al., 1996; Bocherens, 2003; 2015). Mammoths exhibit $\delta^{13}C$ values in the low range of coeval herbivores and $\delta^{15}N$ values significantly higher than all other large herbivores (review in Bocherens, 2015), and also than small herbivores (Baumann et al., 2020). This pattern is consistent all over the geographical distribution of the woolly mammoth, from Western Europe to eastern Siberia, northeastern China and northwestern North America (e.g., Bocherens et al., 1996, 1997; Fox-Dobbs et al., 2008; Bocherens, 2015; Kirillova et al., 2015; Ma et al., 2017) (Fig. 13.1). It is also consistent in time over the period from the early Late Pleistocene until the Holocene in Wrangel Island (Arppe et al., 2019). This isotopic difference is most probably due to the consumption of dry mature grass by mammoths, because this kind of plant food has higher $\delta^{15}N$ values than other grasses and browse consumed by the other herbivores (Bocherens, 2003; Bocherens et al., 2015). In few cases, some horses can show isotopic values overlapping with those of mammoths (Drucker et al., 2015; Wißing et al., 2019), but this is a rare occurrence and the ecological possible meaning of this pattern will be discussed later in this paper. When significant ecological disturbance took place, as in the case of the Late glacial mammoths from the Russian-Ukrainian Plains (Drucker et al., 2018) and of the Holocene mammoths from Saint-Paul Island (Graham et al., 2016), the isotopic values of the mammoths diverged from the usual pattern and can be used as a tracer of breaking down of the optimal mammoth ecosystem.

Most isotopic results on collagen from Pleistocene proboscideans are from woolly mammoth, due to its younger geological age than other extinct proboscideans and the favorable cold climatic conditions for organic matter preservation. A notable exception is the site of Schöningen in northern Germany, where straight-tusked elephants (*Palaeoloxodon antiquus*) that lived before 300,000 years under temperate climatic conditions, were preserved in organic rich sediment and yielded well-preserved collagen in their bones. They also exhibited the distinct nitrogen isotopic signature of woolly mammoths compared to coeval large herbivores (Kuitems et al., 2015), allowing potentially the quantification of the consumption of straight-tusked elephant meat by predators, here large felids (*Panthera*, *Homotherium*), as no human remains have been found to date in this Middle Pleistocene site.

13.3 PROPORTION OF MAMMOTH MEAT CONSUMPTION BY PREHISTORIC HUNTER-GATHERERS

Several recent publications yielded isotopic values on prehistoric hunter-gatherers and associated fauna that allow to evaluate the proportions of mammoth meat consumed in sites following an increasing chronological depth. We will first consider Central European sites, where woolly mammoth (*Mammuthus primigenius*) remains are very abundant (the Moravian sites of Předmostí, Dolní Věstonice II and Pavlov I), then older Upper Palaeolithic sites in Eastern Europe (Buran-Kaya III in Crimea and Kostenki in Russia), and finally sites with late Neanderthals in Western Europe (Saint-Césaire in France, as well as Goyet and Spy in Belgium).

13.3.1. CENTRAL EUROPEAN UPPER PALAEOLITHIC

The Gravettian sites from the Lower Austrian-Moravian-South Polish corridor have yielded huge amounts of mammoth bones associated with abundant archaeological material, including human skeletal remains with clear indication of mammoth hunting (e.g., Musil, 2010; Wilczynski et al., 2019). In this context, an isotopic investigation of the mammal fauna, including one human bone from Předmostí (Bocherens et al., 2015), combined with the newly published isotopic results on Gravettian humans from Dolní Věstonice II and Pavlov I (Fewlass et al., 2019), clearly demonstrated that all the analyzed humans consumed high amounts of mammoth meat, accounting for ~60% of the protein source in the average human diet (Bocherens et al., 2015) (Figs. 13.2, 13.3). This is in great contrast with the prey proportions deduced from the isotopic results obtained on animal predators, with only wolves showing a high mammoth consumption similar to humans, and some scavengers, such as brown bears, wolverines and polar foxes also exhibiting higher than usual mammoth consumption in this site (Bocherens et al., 2015).

Such a high consumption of mammoth meat is not surprising, in view of the huge amount of mammoth bones accumulated and the evidence for mammoth hunting found in these sites, taking place in all seasons (Musil, 2010; Wojtal et al.,

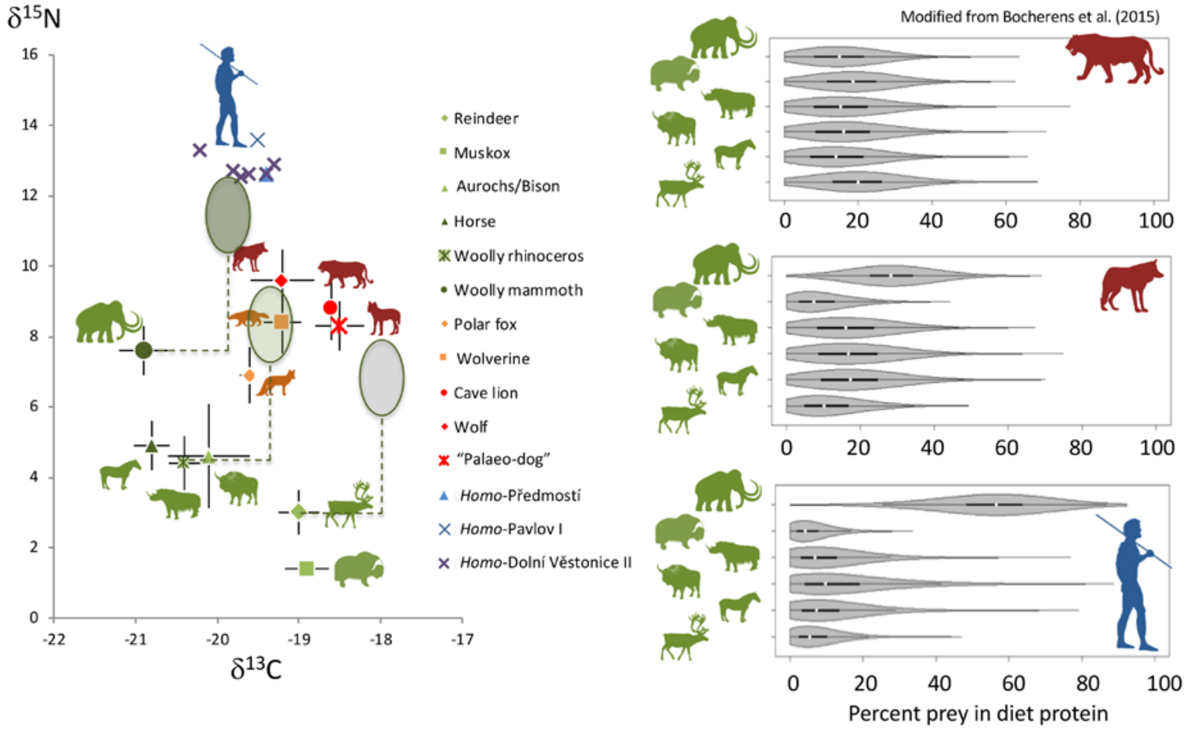

Figure 13.2: On the left, scatter-plot of $\delta^{13}C$ and $\delta^{15}N$ values of bone collagen from herbivores, predators and humans in the Moravian plain sites Předmostí, Dolní Věstonice II and Pavlov I (data from Bocherens et al., 2015 and Fewlass et al., 2019). The ellipses show the projected range of isotopic values for predators of the main prey species. On the right, results of the Bayesian mixing model SIAR showing the proportions of different prey for cave lion, wolf and humans from Předmostí (modified from Bocherens et al., 2015).

2016; Wilczyński et al., 2019; Germonpré et al., this volume). The fact that some scavengers had access to significant amounts of mammoth meat suggests that the carcasses provided not only food resources to humans, but also subsidies for some predators.

13.3.2. EASTERN EUROPEAN EARLY UPPER PALAEOLITHIC

CRIMEA | In the early Upper Palaeolithic site of Buran-Kaya III, an isotopic investigation of humans and coeval fauna also indicated that mammoth was consumed in high proportion by humans (Fig. 13.3; Drucker et al., 2017). This result is more surprising than in central Europe since no mammoth bone was found at the Crimean site. This could be due to the fact that this site corresponds to a hunting station of saiga antelopes during their seasonal migration, therefore representing a small chronological snapshot on human activity that does not reflect the average subsistence strategy of the studied individuals (Crépin et al., 2014). This case study demonstrated how important are the isotopic investigations for reconstructing the contribution of different prey species, especially proboscideans, to prehistoric human diet, in particular when the faunal assemblages correspond to a specialized function of a site. However, these faunal remains provide material to establish the isotopic baselines needed for the interpretation of the isotopic data measured on human specimens.

KOSTENKI | A series of sites dated to the early Upper Palaeolithic (42–30 ka) in western Russia are also dominated by mammoth remains and yielded additionally human bones (Hoffecker et al., 2010; Bessudnov, 2019; Germonpré et al., this volume). Isotopic values of human, wolves and horses have

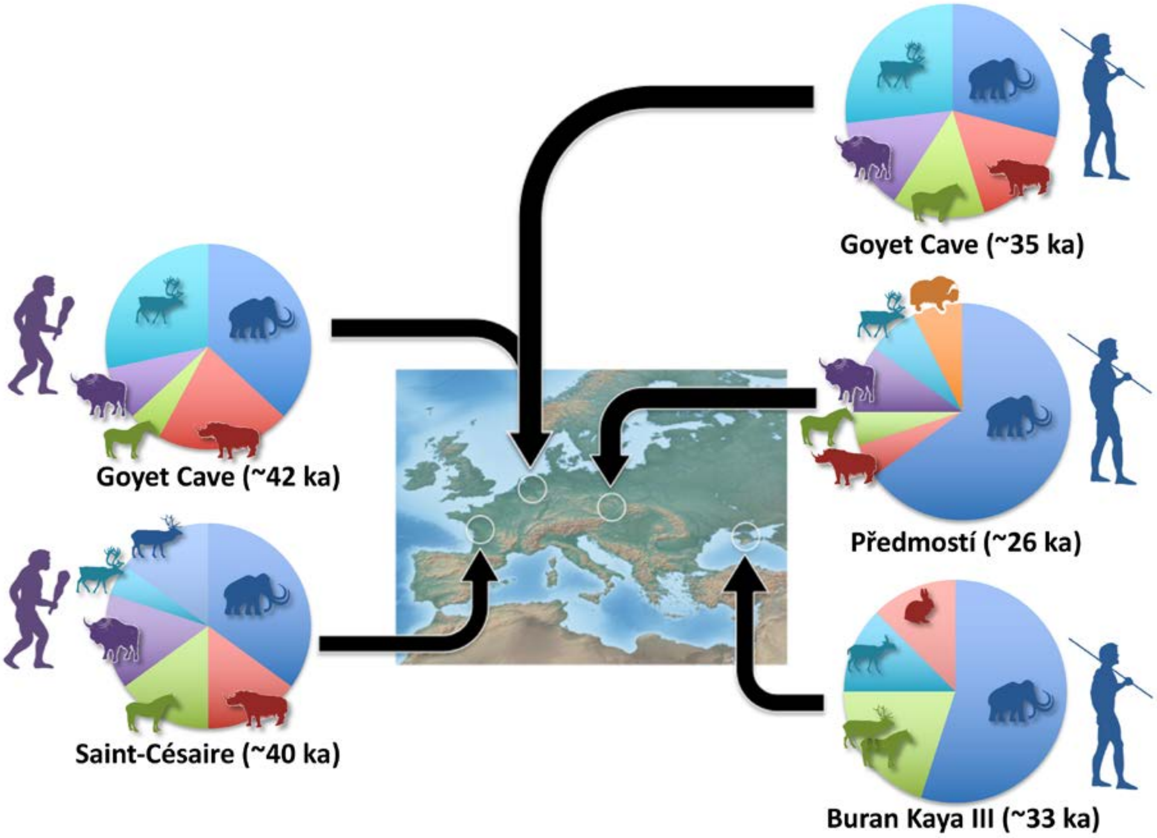

Figure 13.3: Proportion of prey consumption based on carbon and nitrogen isotopic composition of hominins and coeval herbivores in late Neanderthals and early modern humans. Map taken from Natural Earth (naturalearthdata.com). Data are from Wißing et al. (2016, 2019) for Goyet cave, from Bocherens et al. (2005) for Saint-Césaire, from Bocherens et al. (2015) for Predmosti, and from Drucker et al. (2017) for Buran Kaya III.

been measured (Richards et al., 2001; Dinnis et al., 2019), and they are similar to those from Buran-Kaya III (Drucker et al., 2017). Even if the isotopic abundances of mammoth bones have not been analyzed in this site, it is likely that here again, mammoth was high on the menu of humans, due to the similarity of all the other species with those from the Buran-Kaya site in Crimea (Drucker et al., 2017).

13.3.3. WESTERN EUROPEAN LATE NEANDERTHALS AND EARLY MODERN HUMANS

The sites of Spy and Goyet (Belgium) have yielded numerous remains of late Neanderthals, as well as some early modern humans (Semal et al., 2009; Posth et al., 2016; Rougier et al., 2016). In these sites, an abundant mammalian fauna has been also recovered, as well as in the nearby contemporary site of Scladina (Simonet, 1992; Bocherens et al., 1997), providing the possibility to reconstruct the diet of late Neanderthals, early modern humans and animal predators in the same region (Wißing et al., 2016, 2019). Both sites, Spy and Goyet, have yielded mammoth remains (Germonpré et al., 2014; this volume), and a seasonality investigation based on dental wear of mammoth deciduous premolars indicates that mammoths were hunted during all seasons at both sites (Germonpré et al., this volume). The isotopic results clearly indicate a high amount of mammoth ~40% in the protein part of the diet of all Neanderthals, from Spy as well as from Goyet, and also in similar amounts in the diet of early modern humans from Goyet (Fig. 13.2).

The site of Saint-Césaire (Charentes-Maritime, France) yielded one of the most recent Neanderthals in Europe associated to a Chatelperonnian (early Upper Paleaolithic) context (Lévêque and Vandermeersch, 1980; Hublin et al., 2012). This hominin specimen was investigated, together with associated mammals, and yielded results indicating a high amount of mammoth ~30 to 40% (Fig. 13.2; Bocherens et al., 2005; Wißing et al., 2019). The $\delta^{15}N$ values of the Neanderthal specimen are much higher than those measured on hyenas, showing that this scavenger had much less access to mammoth meat, and therefore the hominin had prime access and was most likely the one killing mammoths rather than scavenging them (Bocherens et al., 2005).

13.4 MAMMOTH OR FISH? CONTRIBUTION OF SINGLE COMPOUND AMINO ACID NITROGEN ISOTOPES

In Western Europe, Neanderthals from Saint-Césaire, Spy and Goyet as well as early modern humans from Goyet, present bone collagen carbon and nitrogen isotopic abundances that are in a similar position compared to those of coeval herbivores and predators than in the Central and Eastern European sites of Předmostí and Buran-Kaya III. When the possible contribution of each large herbivore in the diet of hominins and predators is evaluated, using Bayesian mixing models, mammoth always comes out as the most important contributor to the protein part of the diet. Besides mammoth, one other possible food resource could account for such an isotopic pattern in hominin collagen: freshwater fish. Freshwater fish also typically exhibit lower $\delta^{13}C$ and higher $\delta^{15}N$ values than the meat of terrestrial herbivores except mammoth (e.g., Drucker and Bocherens, 2004). Mammoth is much more often found in Middle Palaeolithic and early Upper Palaeolithic sites than fish, but it cannot be totally excluded and this could be the source of an uncertainty in the diet reconstruction leading to an overestimation of mammoth consumption. Fortunately, a new approach allows sorting out this uncertainty: the single compound amino acid nitrogen isotope analysis (Naito et al., 2016).

This approach takes advantage of the difference of nitrogen isotopic fractionation between source amino acids that cannot be synthesized by an organism (such as phenylalanine), and remain essentially unchanged along the food chain and the trophic amino acids that can be synthesized by an organism with a significant fractionation (such as glutamic acid). Moreover, the nitrogen isotopic values of these amino acids are clearly different in terrestrial and aquatic foodwebs (e.g., Naito et al., 2013). When both types of amino acids are retrieved from the same collagen molecule, the isotopic difference between them allows distinguishing clearly the origin of the protein part of the food, from a terrestrial or an aquatic foodweb (e.g., Naito et al., 2013). Because this methodology is more technologically challenging than the isotopic measurements on bulk collagen, it has been applied so far to few adult hominin specimens, i.e. the Neanderthals from Spy (Naito et al., 2016) and the early Upper Palaeolithic modern humans from Buran Kaya III (Drucker et al., 2017). In both cases, the results indicate clearly a purely terrestrial diet, excluding fish and other freshwater resources as the possible reason for the high $\delta^{15}N$ values. This conclusion can very likely also apply to the other sites considered above.

13.5 POSSIBLE ECOLOGICAL IMPACT OF MAMMOTH HUNTING ON LATE PLEISTOCENE ECOSYSTEMS

With such a high consumption of mammoth meat by late Neanderthals and early modern humans in Europe, the question arises whether this killing of mammoths had a significant impact on the mammoth populations (e.g., Brook and Bowman, 2004; Haynes, 2018), and possibly through a trophic cascade effect on the whole ecosystem (e.g., Malhi et al., 2016; Smith et al., 2019). First, it is necessary to see if human predation on mammoth was something unique or merely replacing predation by animal predators, and second if there is evidence of ecological disturbances that can be linked to a depletion of mammoth populations.

So far, isotopic tracking of Late Pleistocene animal predator diet has failed to demonstrate a high level of predation on proboscideans (e.g., Bocherens et al., 2005, 2015; Bocherens, 2015), even for the morphologically derived saber-toothed felids, such as *Smilodon* and *Homotherium*, for which proboscidean specialized hunting has been inferred based on other lines of evidence, especially for North American sites (e.g., Rawn-Schatzinger, 1987, 1992; Meachen-Samuels and Van Valkenburgh, 2010; Graham et al., 2013; Van Valkenburgh et al., 2016). Since this low predation on proboscideans by Late Pleistocene predators is also observed in areas devoid of prehistoric humans, such as eastern Siberia and Alaska/Yukon before 30,000 years ago (Bocherens, 2015), it shows that this proboscidean predation was low during the Late Pleistocene in the absence of humans. Therefore, none of the large predators (cave lion, cave hyena, wolf, brown bear) occurring in Eurasia during the Late Pleistocene seems to have been a regular predator of woolly mammoth or other proboscideans. This leaves only prehistoric humans exerting a predatory pressure on mammoth that was not occurring through predation by animal predators. It is therefore likely that human hunting led to increased mortality of mammoths, an animal that probably had a rather low reproductive turnover, although African elephant populations can recover successfully from mass mortality events (Haynes, 1991). Interestingly, palaeogenetic research has shown that a mitochondrial clade of mammoths coming from Siberia expanded into Europe between ~35,000 and 15,000 years ago (Palkopoulou et al., 2013; Fellows Yates et al., 2017), and prehistoric human hunting probably contributed to the decline of mammoth populations in Europe, facilitating the immigration of Siberian populations into Europe (Fig. 13.4). In ecological terms, this decline of mammoth populations either could have opened possibilities for other herbivores consuming plant resources unused by the missing mammoths or could have led to a collapse of the ecosystem due to the loss of a key ecological function, such as maintaining a patchwork environment and accelerating nutrient recycling (e.g., Zimov et al., 1995).

The isotopic tracking of Late Pleistocene mammal bone collagen not only allows the reconstruction of the proportion of prey consumed by predators and human hunters, but also provides indication on the niche partitioning among herbivores and possible changes linked to different levels of competition among species. For instance, if one species becomes less abundant, another species might take advantage of this new situation and start exploiting the food resources previously consumed by the declining species. Since woolly mammoth is almost systematically the only herbivorous species taking advantage of the forage with high $\delta^{15}N$ values, it is interesting to consider the few cases where another species also occurs in the same range of isotopic values. Among the other herbivorous mammals that regularly co-occur with woolly mammoth, horse has been found in several instances to shift its isotopic distribution towards the one usually exhibited by the mammoth (Fig. 13.4). So far, such a phenomenon has been noticed during the early Upper Palaeolithic in Belgium and in the Swabian Jura, in southwestern Germany (Drucker et al., 2015; Wißing et al., 2019). In both areas, mammoths were intensively exploited, as demonstrated by isotopic tracking of human bone collagen in Belgium (Wißing et al., 2019) or by the abundance of tools and jewelry made of mammoth ivory and bone in the Swabian Jura (Münzel et al., 2017; Wolf and Vercoutère, 2018). Interestingly, this pattern seems to occur in the Upper Palae-

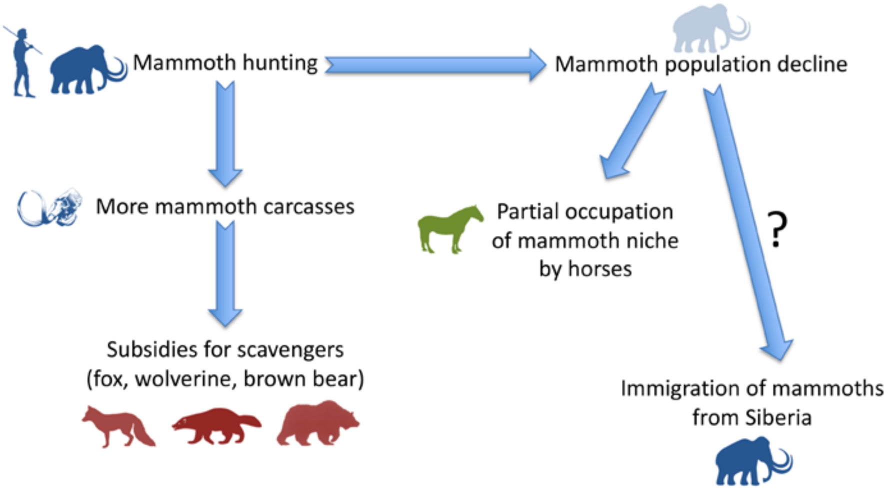

Figure 13.4: Possible ecological consequences of mammoth hunting by early modern humans in Europe.

olithic, but not in the Middle Palaeolithic, although both late Neanderthals and early modern humans hunted and consumed mammoth. One difference could be the intensity of this predatory pressure, linked to the higher population density of modern humans compared to Neanderthals (Conard et al., 2006).

Finally, an additional ecological effect of mammoth hunting by hominins could be to provide scavengers with additional food resources that would otherwise not be available (Fig. 13.4). Such impacts of human subsidies on predators have been documented in recent contexts (e.g., Newsome et al., 2015, Hulme-Beaman, et al., 2016), but few studies have considered this aspect in prehistoric ones (e.g., Bocherens et al., 2015; Baumann et al., 2020a, b). In sites where mammoths were heavily exploited by hominins, isotopic tracking of collagen from predatory species with scavenging habits suggests that some species that could not hunt such a large prey by themselves, e.g., foxes, wolverine and brown bears, had more access to this resource than in other contexts (Bocherens et al., 2015). More studies are necessary to confirm such a trend, but it seems that the carcasses of mammoths hunted by hominins could have provided food resources to some scavenging species and possibly allowed them to thrive.

13.6 CONCLUSIONS

Carbon and nitrogen isotopic tracking with bone collagen has already yielded very important evidence for the high amount of mammoth meat consumption by late Neanderthals in western Europe, and early modern humans in western, central and eastern Europe from around 45,000 to 30,000 years ago. This approach complements efficiently other disciplines, such as zooarchaeology, archaeology and palaeogenetic, and contributes to provide a more accurate picture of the exploitation of mammoths by hominins. In addition, this approach allows evaluation of the ecological impacts of mammoth hunting, on the mammoths themselves, on their potential competitors and on the scavengers taking advantage of a new food resource. As modern humans entered Europe, they already started affecting their ecosystem through the predatory pressure they exercised on a keystone megaherbivore, the woolly mammoth, well before the final extinction of this proboscidean in Europe ~12,000 years ago.

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14. FROM TORTOISES TO ELEPHANTS: THE IMPACT OF ELEPHANTS IN THE BROAD SPECTRUM DIET AT BOLOMOR CAVE (MIS 9–5 SPAIN)

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ABSTRACT

Animal exploitation strategies have occupied a prominent place in the debate about the timing and nature of the modern human behavior. The discussions have basically focused on the ability to make an intensive use of seasonal resources, to hunt large or dangerous animals and to exploit fast-moving small game. Both large-sized herbivores and small prey are therefore considered a key variable to assess fundamental aspects of the evolution of subsistence strategies. In this work we present zooarchaeological data from the Middle Pleistocene site of Bolomor Cave (Valencia, Spain, MIS 9–5e), which has been interpreted as a habitat place. Its taxonomic representation extends from very large-sized herbivores (elephants, hippopotamuses and rhinoceroses) to very small-sized animals (lagomorphs, birds and tortoises), or even exotic animals like macaque. Elephant specimens are documented along the stratigraphic sequence from level Ia, IV, V, XII, XIII and XVII. Most of the elephant individuals are immature and partially represented. Nevertheless, the bone fragments recovered coincide with the general anatomical profile of the medium- and large-sized ungulates, which is mainly characterized by stylopodials, zeugopodials and mandibles. Evidence of human use of small prey from the earliest phases of site occupation (sublevel XVIIc) is also attested in form of cut marks, intentional bone breakages, human tooth marks and burning patterns. The exploitation of small prey, alongside to the very large game identified at the site, indicates a generalist human behavior based on a broad spectrum diet (BSD), which contributes to document the diversity in the lifestyles of the human communities of the European Middle Pleistocene.

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14.1 INTRODUCTION

Foraging behavior models linked to evolutionary ecology have shown that resource intensification can take several forms. Prey choice models predict that the highly ranked prey (those providing greater energetic efficiency in relation to search, hunting, processing and handling costs) will always be taken on encounter; if the rates of encounter with the preferred prey decrease, foragers are expected to expand their diets by including more lower-efficiency resources (Broughton, 1994; Bird and O'Connell, 2006; Clark, 2011). Stiner (2005) proposes that predators can afford to ignore low-ranked prey when high-ranked ones abound, thus favoring a narrow diet that emphasizes specific types of prey. As such, an expansion of food amplitude is expected to be one of the first responses to food stress (Kaplan and Hill, 1992).

A primary method to maximize the nutritional return of an animal is to incorporate body parts with low meat/marrow utility into the diet (e.g., Binford, 1978; Grayson, 1989); therefore, variability in transport patterns can provide valuable information on resource intensification. However, different factors can play a significant role in decisions made about the transport of whole animals or anatomical body parts, including the number of components in the hunting party (or available to help move the carcasses), the distance from the kill site to the consumption place, the size and condition of the carcass and even the time of day (Binford, 1981; Bunn and Kroll, 1986; O'Connell et al., 1988, 1990; Bunn, 1993; Gifford-Gonzalez, 1993; Faith et al., 2009). Unfortunately, it is difficult to identify these factors at the archaeological level. Ethnoarchaeological studies on hunter-gatherer groups, such as the Hadza, have demonstrated that small-sized prey (classes 1 and 2 *sensu* Bunn, 1986) are usually transported whole (Oliver, 1993); however, the interpretation of transport strategies for larger animals is a bit more complex, as multiple variables could intervene. In the case of proboscideans, the Bisa people (Zambia) remove the meat from the limbs and leave the bones at the death site, but the Ituri Forest people (central Africa) move the limb elements to their campsites to extract grease and fat from the bone medullary cavities and cancellous tissues (Crader, 1983; Duffy, 1984; Haynes and Klimowicz, 2015). The common point in most accounts is that there is significant variability in the processing depending on the size and condition of the animal and the number of people seeking meat or other carcass products (e.g., Crader, 1983; Duffy, 1984; Fisher, 1992; Haynes and Klimowicz, 2015).

Beyond measures of transport strategies and carcass use and processing, elephants are considered key elements in ecosystems; observing their behavior is vital for hunting-gatherer groups to develop successful strategies. Elephants know the location of water, mineral and vegetable resources, as well as meeting places, thanks to their complex mental maps (e.g., Douglas-Hamilton, 1972; Moss, 1982). These would also provide easily traceable travel routes, which could be followed by other mammals in their search for water during periods of drought, by carnivores in search of vulnerable prey and by human groups seeking the same resources.

14.1.1 PROBOSCIDEAN CARCASS USE IN THE IBERIAN PENINSULA DURING THE LOWER AND MIDDLE PALAEOLITHIC

The association between lithic tools and megafauna remains a recurring topic in Palaeolithic research, although it has not been without controversy (e.g., Villa, 1990; Haynes, 1991; Martos, 1998; Gaudzinski et al., 2005; Villa et al., 2005). Sometimes proboscidean remains with lithics appear in the same stratigraphic context, but because there are no direct traces on the bones, such as cut marks, percussion marks or intentional bone breakages, it is difficult to support human use of these carcasses with empirical arguments (e.g., Martos, 1998; Mussi and Villa, 2008). This is a recurring problem at many European Pleistocene sites; sometimes taphonomic conditions are linked to the preservation of the record or to external factors derived from the topographic situation of the deposits, leading even some authors to propose that the elephant-human interaction does not become well established until the Upper Palaeolithic (e.g., Frison and Todd, 1986; Fosse, 1998; Gaudzinski et al., 2005; Surovell and Waguespack, 2008).

When analyzing the possible evidence of the anthropogenic processing of elephants in the Iberian Peninsula, the Lower Palaeolithic site of Fuente Nueva-3 (FN-3, Granada, Spain) stands out as one of the oldest (>1.22 Ma; Espigares et al., 2019, this volume). Its elephant record is concentrated in the upper layer of FN-3 and the count of minimal number of elements (MNE) is much lower than the number of identified specimens (NISP), which is due to the abundance of ivory fragments. The presence of coprolites and lithic tools surrounding an incomplete elephant carcass have led Espigares et al. (2013) to suggest that hominins and hyenas (*Pachycrocuta brevirostris*) may have competed for the consumption of this megaherbivore. However, the carcass does not exhibit cut marks or percussion alterations that allow it to be directly associated with human activity. At this point, it is important to mention that the archaeological sites located in this type of context present often problems with both preservation, especially of faunal specimens, and the post-depositional processes related to the geological genesis of the deposits. This fact often prevents the identification of bone surface modifications. However, more important is to highlight the intrinsic difficulty in detecting marks on megaherbivore carcasses (e.g., Huckell, 1979; Crader, 1983; Frison and Todd, 1986).

A similar case can be found at the Áridos 1 site (MIS 9/11, Madrid, Spain), where a small assemblage of lithic tools was associated with the disarticulated carcass of an adult female straight-tusked elephant. The presence of hammer stones, conjoining artifacts and flakes from hand axes led the research team to propose an *in situ* knapping and re-sharpening (Santonja and Villa, 1990; Santonja et al., 2001). Significant differences between Áridos 1 and 2 have been described. In the case of Áridos 2 (MIS 11, Madrid, Spain), the partial skeleton of a large male straight-tusked elephant was preserved as a tight concentration of bones with cut marks on a scapular blade and the ventral side of a rib, which were linked to bulk flesh and viscera removal activities. In addition to these damages, tooth marks likely produced by hyaenids on the distal epiphysis of a humerus have also been identified (Yravedra et al., 2010). The combination of these alterations led Yravedra et al. (2010) to propose the existence of several access episodes and a sequence of actions in which hominins appear to have had early access to the carcass based on the cuts linked to visceral removal. The visceral content of elephant carcasses usually disappears rapidly, taken by the carnivores that access these animals primarily (Haynes, 1991, 2005). The review of the faunal materials from Áridos 2 has allowed for a refinement of the interpretations made in the first stage by Santonja and Villa (1990), where it was proposed that the animal died a natural death and, therefore, an opportunistic subsistence behavior of early humans. The backward torsion of the elephant spine was interpreted as a consequence of the drying of the carcass during its decomposition.

Other examples of associations of proboscidean remains with stone tools come from the Middle Pleistocene sites of Torralba and Ambrona (Soria, Spain; Villa, 1990; Howell et al., 1995; Santonja et al., 1999; Mussi, 2005; Santonja and Pérez-González, 2005; Villa et al., 2005). The last data place Torralba ~200 ka later than Ambrona (Santonja et al., 2014), dated to 350 ka by electron spin resonance/Uranium-series (ESR/U-series; Falguères et al., 2006). Although the presence of lithics and occasional cut marks indicates that humans visited both places, it has also been shown that natural and non-human factors played an important role in the genesis of these sites (Villa et al., 2001). Another place to highlight is the Barranc de la Boella (Tarragona, Spain), with lithic tools and *Mammuthus meridionalis* remains in stratigraphic association (Mosquera et al., 2015). Palaeomagnetic and cosmogenic nuclide analyses point to a 0.96–0.78 Ma chronology for unit II of Pit 1 (Vallverdú et al., 2014). The faunal assemblage shows a poor cortical preservation linked to chemical processes produced by lixiviation in sediments, as recorded at the nearby locality of La Mina (>500 ka; Pineda et al., 2014). Although the poor preservation of the bone surfaces makes it difficult to clarify the origin of modifications, two ribs show striae that seem to bear V-shaped cross-sections and Hertzian cones compatible with anthropogenic cuts. In the case of La Mina, bones of several species show damage that could initially be identified as cut marks, but subsequent taphonomic studies have indicated a possible post-depositional origin related to trampling processes. In the experimental study conducted by Pineda et al. (2014), trampling and cut marks were reproduced and were subjected to chemical alteration with the aim of observing how the diagnostic criteria that define cut marks are modified after an erosive action with chemical origin. These authors determined that at an experimental level, the cuts tend to preserve the symmetry and the cross-section shape, while the shoulder effect, microstriations and barbs tend to disappear gradually as the modifying process progresses. The application of these results to La Mina showed that the marks on the bones were chemically altered and, therefore, lost the diagnostic criteria necessary for a correct identification: a phenomenon that could be extrapolated to the general faunal assemblages from the localities that make up the Barranc de la Boella.

La Solana del Zamborino (Granada, Spain) is another archaeological site in Iberia that yields both proboscideans and stone tools. Its chronology has been a subject of controversy, although new magnetostratigraphic data suggested an age range between 480 and 300 ka, closer to the age of traditional Acheulean sites in Europe (Álvarez-Posada et al., 2017). Although the recovered materials have been only partially studied, *Mammuthus meridionalis* remains have been identified in the upper level (or level A) and *Palaeoloxodon antiquus* in the lower level (Ros-Montoya, 2010). The absence of anthropogenic marks on these specimens makes it difficult to establish a direct relationship between the human groups of Guadix-Baza and these large animals at the site.

With more recent chronologies, the PRERESA site (Madrid, Spain) was deposited during the second half of MIS 5, according to the OSL date of 84.126 ± 5.633 ka (Panera et al., 2014). Nevertheless, an older age was obtained by ESR, which dates the deposit within MIS 6 (Moreno et al., 2019). This site yielded 82 proboscidean bones belonging to one individual over a 130-m2 surface, although the highest concentration of industry and faunal remains was found in a 36-m2 area. The good preservation of cortical bones led to the identification of cut marks on six shaft fragments (Yravedra et al., 2012). In addition, intentional bone breakage is proposed by the presence of percussion damage and green fractures, confirming bone marrow extraction at the site. In other places, such as EDAR Culebro 1 (Madrid, Spain), no cut marks have been found on the *Mammuthus* cf. *intermedius* bones, but rather fresh bone breakages that could suggest an intentional fracturing process (Yravedra et al., 2014). Optically stimulated luminescence (OSL) and amino acid racemization (AAR) dates place this site between 120.541 ± 6.851 ka and 133 ± 28/105 ± 10 ka, respectively (Manzano et al., 2011; Silva et al., 2013).

As can be noted, the above-mentioned sites have the common characteristic of being located in open-air contexts. Only a few locations register proboscidean remains and lithic tools in karstic contexts, one of which is Teixoneres Cave (Barcelona, Spain), where a single fossil of *Mammuthus primigenius* was recovered from unit III, constituting 0.11% of the assemblage (44,210 to 33,060 cal ka BP). The specimen is an upper dP2, which is only present during nearly the first year of life (Álvarez-Lao et al., 2017). The presence of a single isolated dental specimen prevents a clear relationship with the human groups that inhabited the cave, as this type of remain does not usually show marks generated by such agents as humans or carnivores. In any case, its identification in the faunal

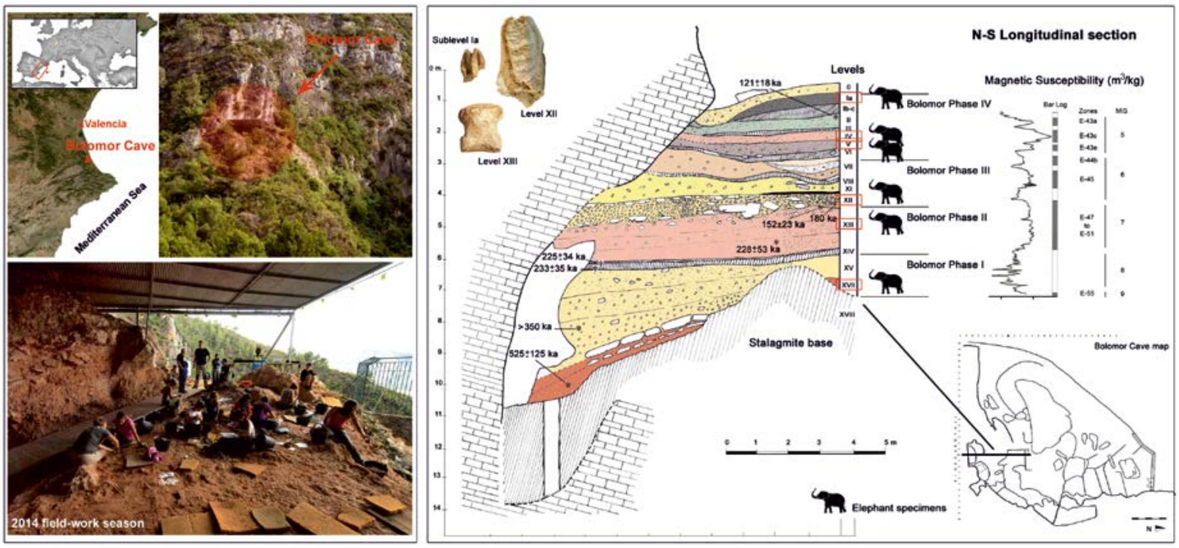

Figure 14.1: Location and stratigraphic profile of Bolomor Cave showing levels with elephant remains and radiometric dates.

record constitutes an exception for being the first Iberian find of a *M. primigenius* dP2. Its presence at Teixoneres reflects a faunal mixture in which cold-adapted species only reached the Peninsula occasionally, during the coldest episodes, sharing habitats with the local faunas instead of replacing them (Álvarez-Lao et al., 2017).

The Bolomor Cave site (MIS 9–5e; Valencia, Spain) is an interesting case study in the karst environment, as elephant remains, as well as other megafauna species —e.g., hippos, rhinos— show anthropogenic marks that allow their presence in the cave to be linked to the activity of the human groups. Our objective here is to present at the taphonomic level the proboscidean remains from the Bolomor sequence and include them within the broad spectrum diet (BSD) identified at the site (Blasco and Fernández Peris, 2012; Blasco et al., 2013a).

14.2 ARCHAEOLOGICAL AND GEOLOGICAL SETTING: BOLOMOR CAVE

The Bolomor Cave site (Fig. 14.1) is located on the southern slope of the Valldigna, ~2 km SE of Tavernes de la Valldigna (Valencia, Spain) and ~100 m above sea level. The cave belongs to the set of karstic forms developed along the northern face of the Mondúver mountain range.

The sedimentary sequence of Bolomor is formed by allochthonous material depositions of colluvial origin, along with other gravitational depositions from ceiling and wall detachments due to tectonic or weathering processes. This sedimentary filling rests directly on the Cretaceous rock that begins with lithochemical layers in the form of stacked calcite mantles. In these, layers of pure crystallized carbonate alternate with others that include ceiling detritic materials and without the presence of archaeological remains. On this base layer, others are deposited with subhorizontal projection and variable thicknesses depending on the area. The stratigraphy has 17 geo-archaeological levels from wall to ceiling in the western sector of the site (type profile), registering recurrent breccia processes with different carbonation degrees depending on the level (Fig. 14.1; Fumanal, 1993; Fernández Peris et al., 1994, 1997; Fernández Peris, 2007). An AAR dating on the dental enamel of 525 ± 125 ka has been obtained at level XVII. Thermoluminescence (TL) results have established values of 233 ± 35 and 225 ± 34 ka at level XIV and 152 ± 23 ka at level XIII. Finally, level II has provided an absolute dating by TL of 121 ± 18 ka (Fernández Peris, 2007). There is currently a programme underway, radiometric dating by OSL, ESR and palaeomagnetism, which will further refine the chronology of the entire sequence.

The faunal assemblage consists so far of 30 species (Table 14.1), including primates, carnivores, herbivores and what could be considered small prey from a zooarchaeological approach (rabbits, birds and turtles). The taxa with a higher representation along the stratigraphic sequence are red deer (*Cervus elaphus*) and horse (*Equus ferus*), followed by auroch (*Bos primigenius*), fallow deer (*Dama* sp.), thar (*Hemitragus bonali* and *Hemitragus cedrensis* at level IV), giant deer (*Megaloceros giganteus*), wild ass (*Equus hydruntinus*), steppe rhinoceros (*Stephanorhinus hemitoechus*), wild boar (*Sus scrofa*), macaque (*Macaca sylvanus*), elephant (*Palaeoloxodon antiquus*) and hippopotamus (*Hippopotamus amphibius*), among others. Although carnivores are occasional, remains of *Ursus arctos*, *Ursus thibetanus*, *Canis lupus*, *Panthera leo*, *Lynx pardinus*, *Vulpes vulpes* and *Meles meles* have also been recovered (Sarrión and Fernández Peris, 2006; Blasco and Fernández Peris, 2010; Fernández Peris et al., 2014). It is also important to highlight the presence of small animals, such as rabbits (*Oryctolagus cuniculus*), hares (*Lepus* sp.), birds (e.g., Passeriformes including Corvidae; Galliformes including Phasianidae; Columbidae; Anatidae), tortoises (*Testudo hermanni*) and occasionally fish (Salmonidae). The percentage of leporids at level IV and Anatidae at level XI together exceeds 50% of the total minimum number of individuals (Blasco and Fernández Peris, 2009, 2012; Blasco et al., 2013a).

Thus far, seven human bones and dental specimens have been recovered in total. Some come from the screening of sediments generated by the 1930s quarry works in the cavity, while others have been recovered during the excavation process, thereby having a clear stratigraphic location. Arsuaga et al. (2012) propose that the morphology of Bolomor human specimens is compatible with that of the European human fossils of the European Middle Pleistocene.

The lithic industry from Bolomor has been classified as a techno-complex of the early Middle Palaeolithic, which is older than the classical regional Mousterian, although without connection to the Acheulean industries (Fernández Peris, 2007; Fernández Peris et al., 2008). The lithic record is composed of more than 50,000 pieces, of which only 11% are retouched tools. The typological and technological characteristics allow us to define the lithic assemblage as a techno-complex of small flakes (with non-laminar microlithism) and as having a predominance of side-scrapers and denticulates. The pieces feature intense reuse and recycling in the upper levels (Fernández Peris, 2007; Cuartero, 2008). The raw materials consist mainly of flint, limestone and quartzite, and they come from marine, colluvial and fluvial rocks located at areas near the site, but also from more remote areas such as the Xùquer and Serpis basins (~15 km from the site). The variability identified throughout the sequence is limited and seems to be marked by the occupational characteristics of each level. In fact, the assemblages acquire some complexity in the most recent levels of the sequence, when occupations seem to have been more intense (Fernández Peris, 2007). It is also worth mentioning that several bone retouchers have been recovered at levels XVII, XIII and XII, and they demonstrate the inclusion of softer materials within the lithic operating sequences (Blasco et al., 2013b; Rosell et al., 2015; Blasco, 2019).

Evidence of the controlled use of fire has been documented at levels II, IV, XI, XII and XIII (Fernández Peris et al., 2012). Hearths from Bolomor are morphologically simple, with no apparent overlays and flat bases. Their appearance is lenticular, with diameters between 30 and 120 cm and an average thickness of 5–10 cm. One of the four hearths from level IV also includes thermally altered centimeter-sized clasts at its base. Level XI yielded seven simple hearths without internal structuring and that seem to correspond to short-term combustions according to experimental reproductions (Fernández Peris et al., 2007). Finally, two combustion structures have been documented at sublevel XIIIc that show a preparation of the area prior to ignition with stones at the base. An AAR dating of 228 ± 53 ka on malacofaunal remains from the area around the hearths was carried out by the Biomolecular Stratigraphy Laboratory of Madrid, Spain. This chronological frame places Bolomor Cave as one of the oldest evidence of the controlled use of fire in southern Europe to date (Fernández Peris et al., 2012; Vidal-Matutano et al., 2019).

14.3 METHODS

The methodology of the faunal analysis in this study has followed the published standards for Taphonomy, with special emphasis on bone modifications produced during carcass processing (e.g., Lyman, 1994, 2008).

The high degree of fragmentation in Bolomor bone assemblages has made it difficult to conduct taxonomic and anatomical identification. Nevertheless, the "unidentified" fragments have been included in the zooarchaeological analysis by classifying them anatomically according to their morphological characteristics into long bones, flat bones and articular bones (e.g., carpal, tarsal and patella) and, at a taxonomical level, into body size classes that depend on the animals' weight and age (Bunn et al., 1988; Blasco et al., 2013a): 1) very large size or classes 5–6 (taxa weighing >1,000 kg; e.g., elephant, rhinoceros, hippopotamus), 2) large size or class 4 (300–1,000 kg), 3) medium size or class 3 (100–300 kg), 4) small size or class 2 (20–100 kg), and 5) very small size or class 1 (<20 kg). Dental replacement and wear have been used as indications to determine the age at death of the animals that make up the assemblage, as well as the degree of bone epiphysation and cortical tissue type (compact in adults or more porous in immature individuals). The accounting of the analyzed specimens has been carried out according to indices, such as the number of specimens (NSP), number of identified specimens (NISP), the minimum number of elements (MNE) and minimum number of individuals (MNI). These indicators allow the minimum anatomic units (MAU) and their relative frequencies to be established (Emerson, 1993).

Bone surface modifications that are produced by biological agents (mainly hominins and carnivores) have been treated at both the macroscopic and microscopic levels. For this, a binocular magnifier (120×) has been used systematically. Selected specimens have also been observed using a 3D digital microscope (HIROX KH-8700). Regarding anthropogenic damage, special attention has been paid to cut marks (e.g., Lyman, 2008), which have been grouped into incisions, sawing marks, chops and scraping marks. Other characteristics, such as their location and orientation have also been noted. The criteria described by Maguire et al. (1980) and Blumenschine and Selvaggio (1991) have been used to identify carnivore damage. As with the cut marks, alterations were recorded by considering the anatomical portion where they are located. Bone fragmentation has been analyzed following the nomenclature described by Villa and Mahieu (1991). In addition, recent (during or after excavation) or old fractures (at or close to the time of deposition) were distinguished according to changes in color at the edge and in the angle that the breakage plane presents. To identify anthropogenic percussion marks, we used the diagnostic elements defined by Blumenschine and Selvaggio (1988), Capaldo and Blumenschine (1994), Domínguez-Rodrigo and Barba (2006) and Pickering and Egeland (2006).

Bone thermal alteration has been analyzed in terms of presence/absence and based mainly on color changes and other physical alterations, such as fissures, fractures or cracks (e.g. Stiner et al., 1995). The intensity degrees have been classified into six categories: grade 0 for unburned bones and grade 5 for calcined ones. As in the case of the other alterations, the anatomical area where burning appears has also been noted.

Finally, faunal specimens were also analyzed for post-depositional alterations that include root etching, fissures, calcite coating/breccia and black

NISP	Ia	Ib-c	II	III	IV	V	VI	VII	VIII	XI	XII	XIII	XIV	XV	XVIIa	XVIIc
Pisces indet.					2					1						
Testudo hermanni	465	10	9	67	526	84				4		4		4		
Bufo sp.					4										1	
Pyrrhocorax sp.					6											
Corvidae indet.					20											
Passeriformes indet.					25						13				5	9
Phasianidae indet.					24										18	10
Galliformes indet.					19						8				8	
Cygnus olor											1					
Anas sp.					29						21					16
Aythya sp.					34					202						
Anatidae indet.															4	
Columba sp.					34											
Strigidae indet.					1											
Aves indet.	32	3			17	18						2		22		
Castor fiber										2	2					
Oryctolagus cuniculus	167	28	5	52	789	297				262	135	182		1156	620	457
Lepus sp.		1						1							5	
Macaca sylvanus					1						2			1		
Palaeoloxodon antiquus	11				5	2					3	8			4	4
Meles meles		3														
Ursus arctos				2	1	1										
Ursus thibetanus	2												1			
Vulpes vulpes					2											
Canis lupus	2				2							2			4	
Lynx pardinus					2						1					
Panthera leo					3											
Carnivora indet.	2	3		2	5	1						2		1		
Equus ferus	28	4	1	5	65	2				2	165	11		41	77	56
Equus hydruntinus	3	2	1		16											
Stephanorhinus hemitoechus		1		1						3	6	2		3	8	1
Sus scrofa	17	1		7	115	3										
Hippopotamus amphibius	4	2		3	46	2										
Dama sp.	9	3	1	2	91	6				4	17	5		4	27	13
Cervus elaphus	271	18	7	55	647	18	3			55	325	51		50	177	132
Megaloceros giganteus										2	5			2	10	8
Cervidae indet.	20	4	1	4								1		5		
Bos primigenius	146	11	12	61	213	16	3		1	2	35	2		1	24	22
Hemitragus bonali										16	4	12		23	28	6
Hemitragus cedrensis	4	1	1	4	121	2										
Caprinae indet.	36	2	4	5		19	1					5		7		

Table 14.1: Number of identified specimens (NISP) throughout the stratigraphic sequence of Bolomor Cave. Data from levels Ia, Ib-c, II, III, V, VI, VIII, XIII and XV were taken from Fernández Peris (2007), and data from levels IV, XI, XII and XVIIa/c were taken from Blasco and Fernández Peris (2012) and Blasco et al. (2013a). *Lepus* sp. data were taken from Sanchis Serra and Fernández Peris (2011) and *Ursus thibetanus* from Sarrión and Fernández Peris (2006). NISP shown in *Palaeoloxodon antiquus* corresponds to a material review that includes specimens from recent excavations.

	Ia	IV	V	XII	XIII	XVIIa	XVIIc	NISP
Teeth	8	5	2	1	3	4	4	27
Maxilla					1			1
Mandible				1				1
Humerus	3							3
Tibia					2			2
Carpal/tarsal				1				1
Phalanx					2			2
NISP	**11**	**5**	**2**	**3**	**8**	**4**	**4**	**37**

Table 14.2: Proboscidean specimens (NISP) from Bolomor Cave.

stains from manganese oxide deposits (Lyman, 1994).

14.4 RESULTS

The Bolomor stratigraphic sequence yields a high fauna diversity with *Cervus elaphus* as the predominant taxon at all levels, followed by *Oryctolagus cuniculus*, *Aythya* sp. at level XI, *Equus ferus* at XII and *Testudo hermanni* at Ia and IV (Table 14.1; Blasco, 2008; Blasco and Fernández Peris, 2009, 2012; Blasco et al., 2013a; Fernández Peris et al., 2014). The presence of *Palaeoloxodon antiquus* has been registered at levels I, IV, V, XII, XIII and XVII with a total of 37 remains (Table 14.2), being more abundant at levels I (NISP = 11), XIII (NISP = 8) and XVII (NISP = 8). Apart from these remains, 14 fragments of long bone shafts have also been recorded without clear diagnostic elements that allow them to be attributed to the family Elephantidae, but which can be classified into classes 5–6 or a very large-size category (NISP I = 1; XII = 3; XIII = 2; XVII = 8). Most elephant specimens were recovered during the excavation process, thereby having a clear stratigraphic location; nevertheless, others were retrieved from sediments disturbed by 1930s quarry works. In these cases, their stratigraphic attribution was conducted based on the sedimentological criteria of the breccia in which the fossils were embedded.

Most of the recovered specimens are dental fragments, both molars and tusks (NISP = 27). An almost complete mandible (with the lower edge preserved) of an immature individual in the case of level XII and a maxillary fragment in XIII have also been retrieved; the remaining specimens correspond to acropodials (NISP = 2) and basipodials (NISP = 1) and mostly to the upper and intermediate limb bones, highlighting the distal humerus (NISP = 3) and the tibia (NISP = 2). Of the 37 fragments identified at the taxonomic level, only 23 allow the age at death to be established; among these, 15 belong to immature individuals (65%). This fact contrasts the age profile determined for the rest of the Bolomor animals, where adult individuals predominate in classes 2–4 with percentages ranging between 92% at level XVIIa and 83% at level IV (Blasco and Fernández Peris, 2012; Blasco et al., 2013a). On the contrary, the skeletal profile of elephants does seem to fit *grosso modo* with that documented for ungulates of classes 2–4, which is characterized by a high representation of cranial and appendicular bones and an almost total absence of vertebrae and ribs, especially marked in classes 3–4 (Fig. 14.2).

The high presence of dental fragments (73%) is a limitation in the search for taphonomic signals of anthropic origin, as the teeth do not usually bear cut marks or other evidence resulting from the nutritional use of carcasses. Despite this, cut marks have been identified on a right mandible of an immature elephant individual from level XII (Fig. 14.3B). This specimen shows five incisions on the vestibular surface of the mandibular body, following an oblique orientation that tends towards

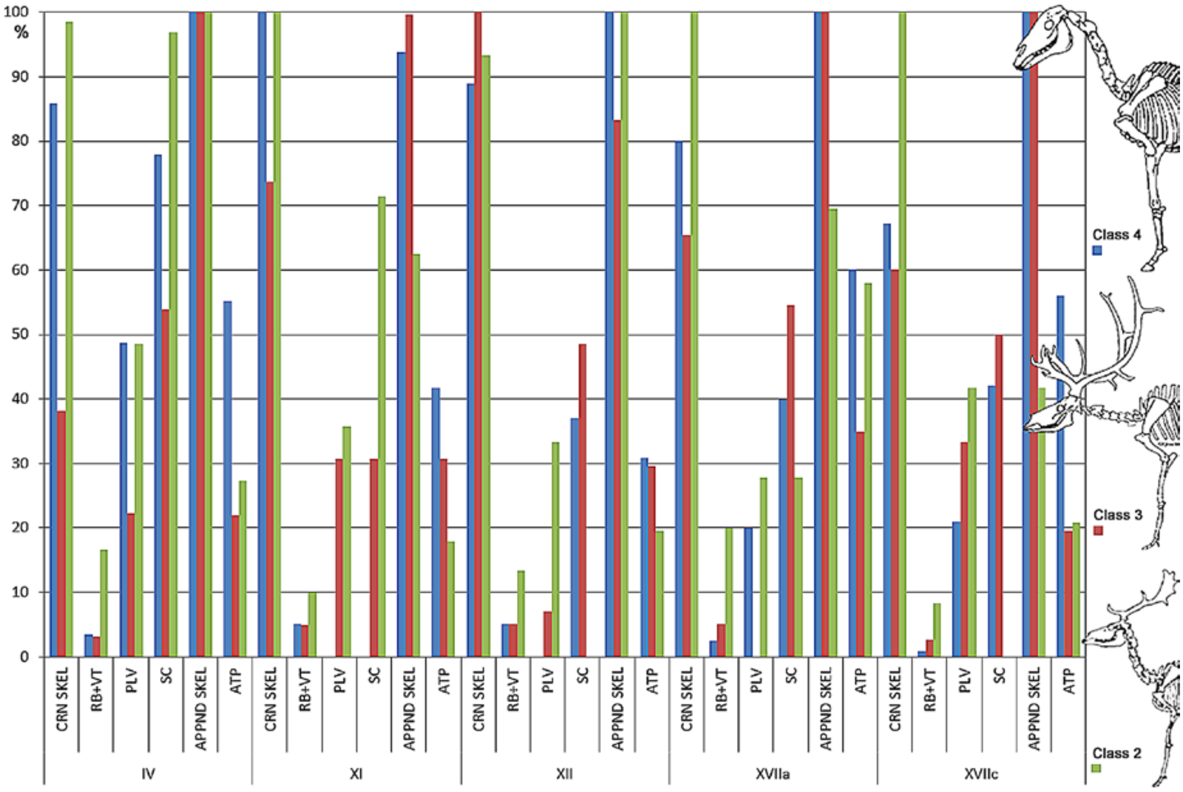

Figure 14.2: Graphic representation of anatomical profiles (%MAU) of classes 2–4 from levels IV, XI, XII and XVII. Abbreviations: CRN SKEL = cranial skeleton; RB+VT = ribs and vertebrae; PLV = pelvises; SC = scapula; APPND SKEL = appendicular skeleton; ATP = autopodial bones.

a longitudinal and straight arrangement (with a slightly curved tendency in one of the striations). The presence of these modifications points to defleshing activities related to the removal of a cheek. The remaining proboscidean bones do not show clear anthropogenic marks, although their fracture planes indicate a fresh state at the moment of breaking open, showing mostly curved/V-shaped planes, oblique angles and smooth edges (68%). Thermo-alteration is present on the proboscidean remains that come from levels I and IV, with nine affected specimens in total (24%). The observed alteration degrees are 2 and 3, which describe brown and to a lesser extent blackish colors, with both partial and widespread occurrence.

The carnivore activity is very low or practically absent in animals of classes 2–4, with percentages between 0.5% at level IV and 5.8% at level XII (see Blasco and Fernández Peris, 2012 and Blasco et al., 2013a for more details). In the case of elephant specimens, partial loss of cancellous tissue has been detected, especially on epiphyses, sometimes associated with moderate erosion of the cortical. This is especially visible in the case of a first phalanx from level XIII (Fig. 14.3A). Apart from this damage, black stains from manganese oxide deposits (NISP = 25; 67%) and calcite coating/breccia (NISP = 21; 57%) have been identified as predominant post-depositional alterations. These modifications indicate that the cave was relatively damp, with intermittent dry periods, although the cracking rarity suggests that the dampness was more or less constant without abrupt changes. Damage in the form of root etching has also been recorded in 27% of the proboscidean specimens (NISP = 10), indicating the entry of light into the cave. On the contrary, no remains have been detected that present visible degrees of rounding and polishing that would suggest dynamics of significant spatial dislocation.

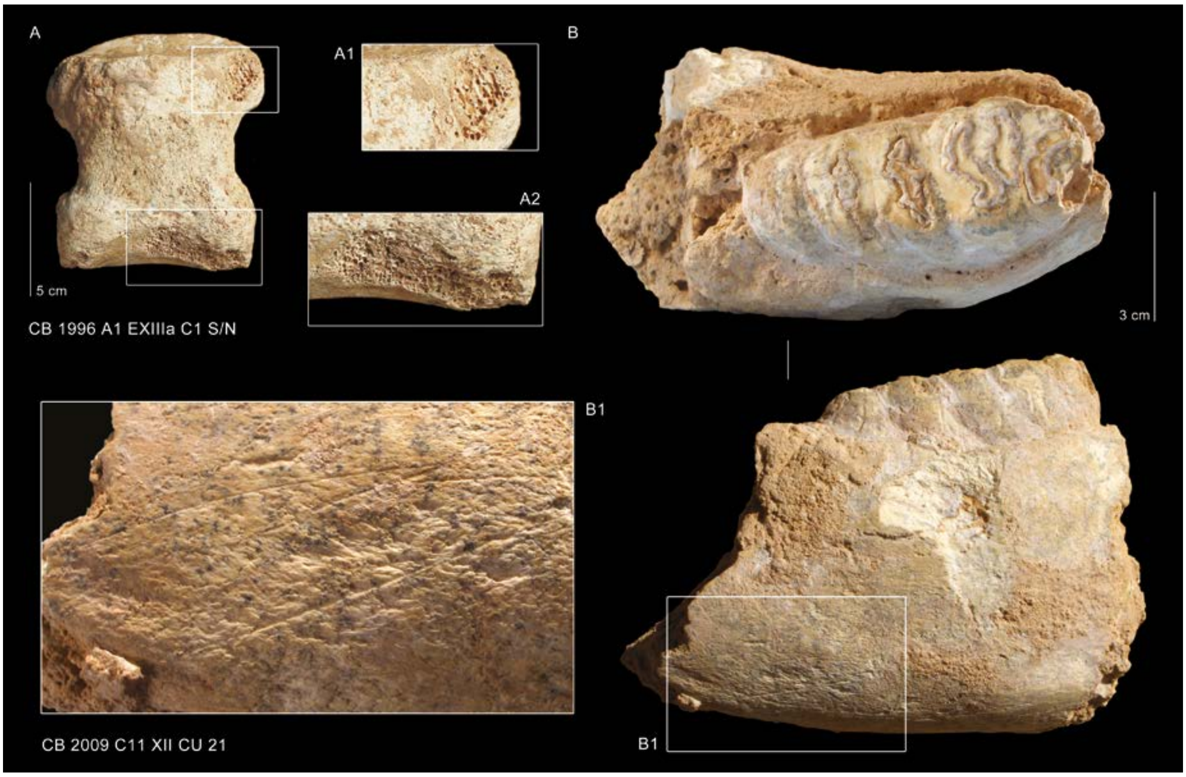

Figure 14.3: Elephant first phalanx with cortical tissue loss on articular edges (**A**) and elephant mandible showing cut marks on body (**B**).

14.5 DISCUSSION AND CONCLUSIONS

Human hunting of medium-sized ungulates is commonly accepted in Palaeolithic research; however, megafauna procurement through this technique is still under debate (Lupo and Schmitt, 2016). Binford (1987) suggested marginal scavenging as the main strategy for procuring elephants. In contrast, the hunting of proboscideans by prehistoric humans has been suggested at several Middle (e.g., Germonpré et al., 2014, this volume) and Upper Palaeolithic sites (e.g., Fladerer, 2003; Bosch et al., 2012; Brugère, 2014; Germonpré et al., this volume), mostly based on indirect zooarchaeological evidence. The truth is that determining whether these animals were hunted or were part of opportunistic activities related to secondary accesses to resources is a difficult issue to address, especially in such localities as Bolomor Cave. However, this is not only difficult at sites interpreted as habitat places in caves, but also in open-air sites. These localities usually present numerous taphonomic problems, which often make it difficult to identify anthropogenic bone alterations and, consequently, zooarchaeological interpretations. In addition, it should also be borne in mind that the high proportion of biomass available in animals the size of an adult elephant, rhinoceros or hippopotamus makes it difficult for the lithic tool to contact the bone when the access is primary. That is, the amount of meat available through this type of access does not favor the continuous contact of the stone tool with the processed skeletal element (unlike in a secondary access, where the extraction of dried meat attached to the bone would favor a higher proportion of sawing marks and prominent incisions). Some ethnographic studies confirm this fact by describing how large muscle masses, cartilage and periosteum thickness in the elephant carcasses make it difficult for the lithic tool to come in contact with the bone after disarticulating (e.g., Huckell, 1979; Crader, 1983; Frison and Todd, 1986). In fact, most proboscidean-lithic tool sites have one aspect in common, regardless of how varied the records are: the absence or scarcity of exploitation traces of proboscidean meat by humans (Gaudzinski et al., 2005). Despite this, and considering these limitations, some authors suggest the development of hunting strategies on these animals at such sites as Biache-Saint-Vaast (France; Auguste, 1995) or La Cotte de St Brelade (Jersey, U.K.; Scott, 1980; but see also Scott et al., 2014 and Smith, 2015). Scott (1980) proposed the existence of complex hunting techniques that would take advantage of the physical environment to facilitate capture —mammoth drive events—–from the megafaunal bone heaps of layers 3 and 6.1 of La Cotte. However, in a subsequent study, Scott et al. (2014) contended that the terrain surrounding the site prevented such drives, and instead suggested a strategy of hunting individual mammoths in the valley beneath the fissure, followed by the transport of selected body parts uphill to the site. New taphonomic analyses conducted by Smith (2015) confirm that Neanderthals occasionally exploited megafauna species (mammoth, woolly rhino) at this site; however, their acquisition and role in the human diet still remain ambiguous. In other localities, another type of access has been suggested in which there may not be direct anthropic intervention in the death of animals. These are natural traps in lakes, where animals with a significant weight could get caught in the mud. An example of this phenomenon is suggested at La Polledrara (Italy), where elephant bone tools identified as human-made were also retrieved (Anzidei, 2001; Anzidei and Cerilli, 2001). For Poggetti Vecchi (Italy) Aranguren et al. (2019) proposed that the elephants died due to natural causes and were butchered soon after, as minimal carnivore damage was observed. In addition, the lack of weathering led these authors to suggest that 1) the butchery was carried out onshore and then the bones rapidly ended up submerged or 2) the bones were semi-submerged while being defleshed and were completely underwater almost immediately after butchery. Nevertheless, it has not been possible to distinguish between a possible primary (and immediate) access and an anthropic use after the natural death of elephants at a large number of sites, such as in Torralba and Ambrona in Spain (Villa et al., 2005) and Kärlich-Seeufer in Germany (Gaudzinski et al., 1996).

Beyond the procurement method, elephants are an ideal food source to meet human nutritional needs due to their combination of protein and fats, with half the potential calories contained in fats (see Ben-Dor et al., 2011 for more details; Ben-Dor and Barkai, this volume). Isotopic studies provide direct evidence of the consumption of proboscideans and indicate recurrent consumption in specific European environments (Bocherens, 2011; Bocherens et al., 2015; Bocherens and Drucker, this volume). It has been suggested that high isotope values could only be the result of habitual dependence on terrestrial megafauna and that mammoths could have been the most important protein source (Drucker and Bocherens, 2004). Nevertheless, there have been criticisms of methodological and interpretation problems with stable isotope analysis, including our way to understand how the carbon isotopic signature is related to other prey species —that is, how δ13C is consumed by herbivore taxa with different diets (e.g., Lee-Thorp and Sponheimer, 2006). Another criticism is that most of these isotopic studies have been undertaken on Neanderthal fossils located within the northern area of Neanderthals' range and therefore, within very specific ecosystems. This fact has undoubtedly limited the generalizability of the findings, because as soon as new data from the southern and western regions were added, a more varied diet containing plants and occasionally marine resources emerged (Salazar-García et al., 2013; Fiorenza et al., 2015). Nevertheless, and despite the fact that regional variation in the Neanderthal diet is currently assumed, terrestrial meat continues to show up as a major resource in all the studies. The importance of proboscideans in the Palaeolithic diet is further emphasized through sites such as Bolomor Cave, to which selected anatomical parts of the elephant body were transported. Other examples are found at the Neanderthal site of Spy, in Belgium, and the Early and Late Palaeolithic site of Ma'anshan in China (Zhang et al., 2010; Germonpré et al., 2014, this volume). In the case of Bolomor, the skeletal profile of elephants is very biased, with a primary representation of cranial elements (mandible, maxilla and dental fragments), limb bones (tibia, humerus) and, to a lesser extent, basipodials and phalanges. It should be noted that no axial elements or pelvises have been recovered. This fact coincides with the general skeletal representation of ungulates of classes 3–4 from the site, and it leads us to think that the preparation system of the carcass for transport at the procurement place or killing site was similar. The fact that most of the individuals are immature also means that the weight of elephants found in Bolomor is less and, therefore, their transport after dismemberment is more feasible and manageable. Although there are many variables to consider (see e.g., Binford, 1981; Bunn and Kroll, 1986; O'Connell et al., 1988, 1990; Bunn, 1993; Gifford-Gonzalez, 1993; Faith et al., 2009), most ethnographic studies agree that animal weight is an important condition when making decisions regarding the transport of anatomical parts to the habitat place (e.g., Bunn and Kroll, 1986; O'Connell et al., 1988, 1990). Several studies report how some present-day groups, such as the Ituri Forest people, perform a selective transport (limb bones) when the animal has a considerable weight, or they move to the death site, establishing temporary camps around the elephant while the butchery process lasts; other cases are also documented in which groups, such as the Bisa of Zambia, deflesh the carcass, leaving the bones at the death site (e.g., Crader, 1983; Duffy, 1984; Fisher, 1992). These latter options could fit with the anthropogenic activities related to animals exceeding 1 tonne of weight, as in the case of Bolomor. That is, the under-representation of such large prey species could be related to the occasional displacement of human groups to the kill sites or explained as the sole and exclusive transport of the animal external resources (e.g., meat) to the site, leaving no archaeological signature after being consumed. Proof of this is the existence of several European open-air sites that have been interpreted as hunting ground or natural traps in which the skeletal representation of very large animals is usually characterized by their high anatomical integrity, such as in the French site of Biache-Saint-Vaast (Auguste, 1995). In some of these localities, intentional bone breakage has also been identified, such as in the PRERESA and EDAR Culebro 1, Spain (Yravedra et al., 2012, 2014). This fact would support the *in situ* anthropogenic use of these animals. In the case of Bolomor, no diagnostic criteria for an intentional fracturing in the form of percussion notches or pits have been detected, but green-bone fractures have been documented, and they could be indirectly related to bone marrow extraction, activity widely recorded on the rest of the ungulates from Bolomor (Blasco and Fernández Peris, 2012; Blasco et al., 2013a). An intentionally broken elephant bone shaft has been registered in Notarchirico (Italy), although it is not specified whether there are percussion marks or only fresh fractures (Mussi, 2005: p. 408).

Unlike most mammals, elephant bones show a different medullary cavity with a prominent cancellous or trabecular tissue. CT scans conducted on limb bones of adult individuals of *Palaeoloxodon antiquus* show small medullary cavities compared to the size of bones, especially in the case of the femur, and the humerus and tibia of older individuals (Boschian et al., 2019). These data contrast those provided by some individuals of *Elephas maximus*, where bones do not include marrow cavities (Nganvongpanit et al., 2017). These characteristics could make the process of extracting fat yellow marrow in elephants more difficult or laborious than in other animals. Although it has been registered that some present-day indigenous groups, such as the Ba-Mbuti of Zaire (Turnbull, 1961; Duffy, 1984), break the elephant limb bones to remove the bone marrow, this practice seems uncommon in other populations (Clark, 1977; Crader, 1983). Some accounts describe a relatively simple technique to obtain bone marrow that consists of partly splitting open the elephant bone, then hanging it in the sun for the oil to drain

(Tabler, 1963); however, the development of this technique would imply the existence of containers of some kind to collect the liquid fat. A fact that attracts attention is the lack of evidence of bone marrow exploitation in the Clovis sites (Haynes, 1991; Haynes and Krasinski, 2010; Haynes and Klimowicz, 2015). Taphonomic analyses carried out at these sites suggest that elephants were hunted regularly, a circumstance that perhaps led to the dismissal of marrow removal because the group already had sufficient food resources (Yravedra et al., 2012). In contrast, Haynes (1991) argues that the limb bone marrow of subadult individuals would have been relatively unattractive, and that the marrow of adults could have had low nutritional value due to malnutrition.

Cut marks can be considered the most direct taphonomic evidence of carcass processing. In the case of Bolomor, incisions on a mandibular fragment of an immature elephant have been identified. These are located on the vestibular surface and can be related to the extraction of the muscular pack that makes up the dewlap. As mentioned, cut marks are uncommon on elephant bones, either due to preservation problems (especially in open-air sites) or by the animal's own anatomy (especially if the carcasses are processed after a primary access; e.g., Huckell, 1979; Crader, 1983; Frison and Todd, 1986). Despite these considerations, most accounts agree that there is significant variability in the processing depending on the size and condition of the animal and the number of people seeking meat or other carcass products (e.g., Crader, 1983; Duffy, 1984; Fisher, 1992; Haynes and Klimowicz, 2015). Despite the limitations, this type of bone surface modification has been detected at several sites. One of the oldest examples of elephant exploitation in Eurasia is Gesher Benot Ya'aqov (Israel), where the damage below the nasal opening, together with the missing basicranial and palatal regions in the cranium, were interpreted as possible deliberate brain extraction and trunk removal (Goren-Inbar et al., 1994). Cut marks were described at the Middle Pleistocene site of Bilzingsleben (Germany; Mania, 1990), as well as at Belchatów (Poland) on a *Mammuthus trogontherii* rib, probably linked to flesh filleting (Pawłowska et al., 2014). Other examples can be found at Kulna (Czech Republic; Moncel, 2001) and Molodova I (Ukraine; Demay et al., 2012). Disarticulation cut marks on proboscidean ribs and long bone shafts were reported at Castel di Guido (Italy; Mussi, 2005), although subsequent taphonomic revisions detected abrasion processes that altered the cut marks substantially (Boschian and Saccà, 2010; Saccà, 2012). In the Iberian Peninsula, Áridos 2 (Spain) yielded a cut-marked scapula and rib, indicating defleshing and evisceration (Yravedra et al., 2010), and PRERESA yielded six cut-marked shaft fragments linked to meat extraction activities (Yravedra et al., 2012). The case of Bolomor is significant, as it is the only peninsular site in cave that records cut marks on proboscidean specimens. This fact establishes an association between elephants and hominins in a different way than that observed at other Middle Pleistocene open-air sites of Iberia, which have been interpreted as kill sites or natural traps (see above). This evidence also completes the broad spectrum diet identified at the site, which includes small prey (e.g., tortoises, rabbits and birds) as well as animals exceeding a weight of one tonne (e.g., rhinoceroses, hippopotamuses and elephants; Blasco and Fernández Peris, 2012; Blasco et al., 2013a).

Some researchers have proposed that proboscidean exploitation was opportunistic and of secondary importance during most of the Pleistocene (Gaudzinski et al., 2005; Smith, 2015). Furthermore, zooarchaeological approaches have demonstrated that while megafauna species appear to be present in many Middle Palaeolithic faunal assemblages, other prey species outweigh them frequently. This might be the case with Bolomor, although we cannot forget that this view comes from a karstic site in which prey above a certain weight were usually brought in selected body parts and therefore, does not reflect the scenario that other open-air localities with elephants describe. Beyond this, the picture that emerges from the Bolomor data indicates, on the one hand, the diverse environments that hominins were able to exploit; and on the other, the decision-making of human groups when selecting resources within the territory and bringing them to the cave. Bolomor Cave helps us to decisively characterize the subsistence strategies of Middle Pleistocene human groups, demonstrating high adaptability, not only in the wide and varied spectrum of prey, but also in the methods and techniques of obtaining resources.

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15. SEASONALITY AT MIDDLE AND UPPER PALAEOLITHIC SITES BASED ON THE PRESENCE AND WEAR OF DECIDUOUS PREMOLARS FROM NURSING MAMMOTH CALVES

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ABSTRACT

Middle and Upper Palaeolithic sites, where mammoths dominate the faunal assemblages, are mainly found in Central and Eastern Europe. At these sites concentrations of skulls, tusks and long bones, interpreted as deliberate constructions, often occur. Rare instances of weapon tip fragments embedded in mammoth bones provide direct archaeological evidence of human hunting. Indirect evidence, such as the accumulation of mammoth bones from multiple individuals with specific ontogenetic ages, occurs more frequently. Based on the eruption sequence and wear of deciduous premolars from mammoth calves, we examined whether a season of death could be deduced from the characteristics of the dentition. Our results suggest that the mammoth hunt was not restricted to the cold half of the year.

15.1 INTRODUCTION

Middle and Upper Palaeolithic sites, where mammoth bones dominate the mammal assemblage, are often interpreted as the camps of mammoth hunters. These sites are mainly found in Central and Eastern Europe, such as Dolní Věstonice and Předmostí (Přerov-Předmostí) in the Czech Republic, Mezhirich and Mezin in the Ukraine, and Kostënki-1/I, Kostënki-11/Ia and Yudinovo in Russia, and date in general to the Gravettian and Epigravettian. At these sites, accumulations of mammoth skeletal elements have been interpret-

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ed as the remains of architectural constructions, places of storage and/or middens (Soffer, 1985; Svoboda et al., 2005, 2019; Germonpré et al., 2008; Iakovleva, 2015; Pryor et al., 2020; Sablin et al., submitted). Some prehistorians assume that these mammoth bones are derived from animals that have been hunted and slaughtered, and then transported to the camp (Germonpré et al., 2008; Péan, 2015). Others have argued that Palaeolithic hunter-gatherers built their camps near the places, where mammoths died from a natural cause (Soffer, 1985). However, at several Upper Palaeolithic sites, direct evidence, such as a fragment of a weapon tip embedded in a bone, testifies to the violence of the mammoth hunt (e.g., Praslov, 2000; Nikolskiy and Pitulko, 2013). In addition, also indirect evidence, such as the accumulation of bones from a multitude of individuals with specific ontogenetic ages, suggests an intentional hunting of mammoths (e.g., Svoboda et al., 2005; Germonpré et al., 2008, 2014; Brugère, 2014; Péan, 2015; Reynolds et al., 2019). In this study, we adhere to the idea that Palaeolithic hunter-gatherers organized mammoth hunts.

Recent elephants create pathways between important places, such as water points, fodder places, mineral springs, and socializing sites (Haynes, 1991, 2017). In Canada, successive mammoth tracks following the bank of a palaeo-river valley indicate that mammoth herds used the same trails over a period of at least two centuries (McNeil et al., 2005). Mammoths probably followed traditional trails for generations. Palaeolithic hunters could have used these paths to track the animals. Alternatively, they could have sneaked up to mammoths that were grazing in moist meadows or drinking water at river shores and attacked while the herd was distracted (Velichko and Zelikson, 2005; Germonpré et al., 2008; Haynes, 2017; Wilczyński et al., 2019). Palaeolithic hunters could have targeted the matriarch first by attempting to strike the animal from the rear side, aiming to hit vital organs (cf. Nikolskiy and Pitulko, 2013) and could then have killed the younger members of the herd. According to Wilczyński et al. (2019), human hunting of mammoths was probably executed by groups of hunters using spear-throwers, throwing spears in sequence. The initial butchering of the hunted mammoths probably took place at the kill site (Germonpré et al., 2008). Body parts of the mammoth carcasses were then brought back to the camp, perhaps with the help of Palaeolithic dogs (Germonpré et al., 2012, 2020).

In this contribution, our goal is to determine whether mammoth hunting was limited to the cold half of the year or occurred as well during warmer seasons. To answer these queries, we assigned an age of death to the dental remains of mammoth calves that were found at several late Middle and Upper Palaeolithic sites, aiming to deduce their season of death. We first provide an overview of the theoretical basis for attributing an age to the dental remains from mammoths and list the material studied here. Then, we present a non-exhaustive list of Middle and Upper Palaeolithic sites in Western, Central and Eastern Europe that contain important mammoth assemblages. Subsequently, we provide the results of the palaeobiological analyses. In the discussion, we compare the obtained results from the studied sites with those from published resources, and summarize some archaeological and palaeobiological consequences. The final section provides our conclusions.

15.2 METHODS AND MATERIAL

Laws (1966) established 30 age groups (I–XXX) for the extant African elephant *Loxodonta africana*, based on the progress of eruption and wear of the cheek teeth, and allocated real ages in African Equivalent Years (AEY) to these groups. In this study, we follow Laws' groups in order to estimate the age at death of woolly mammoth (*Mammuthus primigenius*) calves from their deciduous premolars (DP; both for the upper and lower dentition). The anatomical position of the teeth was identified using the dimensions and number of plates, following Musil (1968), Maglio (1973) and Germonpré (1993), except for the mammoth decid-

Laws' age group	Mammoth calf	References	Age in months	Season of death	Description of deciduous dentition
I	Lyuba	Rountrey et al. (2012)	0–1	early spring	DP2: no/little wear; DP3: germ with complete crown
II	Khroma	Grigoriev et al. (2012); Maschenko et al. (2013)	2	spring	DP2: completely worn; DP3: erupting with first plates in wear
III	-		ca. 3–6	summer	DP2: well worn; DP3: moderately worn
IV	Oimyakonskii	Boeskorov et al. (2007); Rountrey et al. (2012)	7.4	autumn/winter	DP2: lost; DP3: well worn; DP4: erupting/slightly worn
V	-		>12	-	DP3: completely worn; DP4: moderately worn
VI	-	Craig (table A2) in Haynes (1991)	52	-	DP3: almost lost; DP4: only last plates unworn
VII	-	Craig (table A2) in Haynes (1991)	60	-	DP3: lost; DP4: completely worn; M1: erupting

Table 15.1: Comparison of Laws' age groups of elephant deciduous premolars with mammoth calf dentition and their age attribution in months or years, for details see text.

uous premolars from Předmostí, for which the identifications and description by Musil (1968) were used. Complete and fragmentary mammoth deciduous premolars were counted in Number of Identified Specimens (NISP) and in Minimum Number of Individuals (MNI) (Lyman, 1994). Detailed analyses of the microstructure of mammoth tusks allowed to estimate that gestation in mammoths took about 20 to 22 months (Fisher et al., 2014; Grigoriev et al., 2017) and could have been slightly shorter than that of the recent African elephant, which usually has a gestational length of ~22 months (Poole et al., 2011). In mammoths, conception probably occurred in late spring and birth took place in early spring (Rountrey et al., 2012; Grigoriev et al., 2017). Inter-birth intervals had probably a length of ~4 years during which the previously born calf was nursing. Weaning likely occurred, like in elephants, shortly before the next calf was born (Grigoriev et al., 2017). The proposed length of the nursing period of mammoth calves fluctuates between 3 years (Metcalfe et al., 2010) and 5 years (Rountrey et al., 2007). In our study, we will consider a nursing period of ~4 years, up to and including Laws' age group VI. The mammoth deciduous premolars discussed in this contribution are compared with those described by Maschenko (2002), Rountrey et al. (2012), Maschenko et al. (2013), Fisher et al. (2014) and Grigoriev et al. (2017) to estimate their age. A thorough study of the mammoth calf Lyuba, found in the permafrost of the Yamalo-Nenets Autonomous region, Russian Federation, revealed that its DP2 displays little wear and has no cementum in the gaps between the plates. The germ of the DP3 has a fully developed crown but without fully developed enamel, while the germ of the DP4 is incomplete. A comparison with the African elephant age groups as defined by Laws (1966) suggests that this calf can be assigned to Laws' age group I with no/little wear of the DP2, and the DP3 not yet erupted. Based on the number of increments found on the DP2, this calf died when it was ~1 month old, likely in spring (Rountrey et al., 2012). Maschenko et al. (2013) described the deciduous dentition of the mammoth calf Khroma, discovered on the right bank of the Khroma River in Yakutia. The DP2 of this calf is completely worn; the DP3 is erupting with the first three plates in wear. These features correspond to Laws' age group II with slight wear on the protruding DP3. The number of increments on the deciduous premolar suggests that this calf died at an age of ~2 months (Fisher et al., 2014). The detailed analyses of the deciduous premolars of the Oimyakonskii calf, found in the permafrost from Yakutia, Russian Federation (Boeskorov et al., 2007), showed that the DP2s were already lost, the DP3s show advanced wear and the DP4s are unworn. The features of the dentition of the Oimyakonskii calf could correspond with Laws' age group IV, characterized by well-worn DP3 and just erupted DP4. Based on the number of increments of the tusk, this mammoth died when it was 7.4 months old, during autumn or the beginning of winter (Rountrey et al., 2012). Based on these analyses, it seems that the wear of the deciduous premolars in mammoth is advanced compared to the extent of wear observed in recent elephants (Rountrey et al., 2012), as noted also by Haynes (1991). Moreover, it seems to be an accelerated replacement of the DP2s in mammoth compared with recent elephants, perhaps linked to an earlier transmission to a mixed diet or to feeding on mammoth dung (Maschenko, 2002; Maschenko et al., 2013). For Laws' age group VI and above, the age attributions proposed by Craig in Haynes (1991: tables A2, A8) are followed. A summary of the age estimation of nursing calves based on the eruption and wear of the deciduous premolars is presented in Table 15.1.

The mammoth deciduous premolars from Spy and Goyet are housed at the Royal Belgian Institute of Natural Sciences in Brussels (RBINS; Belgium), from Předmostí at the Moravian Museum (Brno, Czech Republic), those discovered at Yudinovo at the Zoological Institute RAS (Saint Petersburg, Russia), and those excavated at Kostënki-21 at the Institute for the History of Material Culture RAS (Saint Petersburg, Russia) and at the Zoological Institute RAS. The dental specimens discussed in this chapter from Spy, Goyet, Kostënki-21 and Yudinovo were studied by one or more of the authors of this contribution. Additional information for the mammoth dentition found at the Russian sites is from Maschenko (2002). The Laws' age group attributions of the deciduous premolars from Předmostí are based on the individual description and figures of the DP2 in Musil (1968: pp. 122–125, pp. 178–179, plate I) and on the figures and description of the DP3 in Musil (1968: pp. 179–181, plates II–VI). Because only 23 of the total number of 73 DP3s are figured and described in Musil (1968), the NISP of the nursing calves less than 1 year old based on the DP2 and DP3 combined, here presented, is a minimum NISP of the Předmostí mammoth assemblage. However, for this contribution, we do not quantify the presence of calf remains by season of death, but we are only interested whether dead calves were present or absent in each of the seasons. In the discussion, we compare the results of the above-mentioned sites with results available from the literature.

15.3 SITES

15.3.1 SPY

Spy cave is one of the richest Palaeolithic sites in Belgium (Fig. 15.1). It was first excavated in the 19th century. Since then, many excavations have been carried out (Rougier et al., 2004; Semal et al., 2009). The discoverers recognized three main archaeological and fauna-bearing levels (Fraipont and Lohest, 1886, 1887; Rucquoy, 1886–1887; De Loë and Rahir, 1911). Spy, like the Goyet cave (see below), was used alternately by humans and carnivores. Each level represents likely a palimpsest. The most important Palaeolithic assemblages can be assigned to the Middle and Upper Palaeolithic, including the Mousterian, Lincombian-Ranisian-Jerzmanowician, Aurignacian and Gravettian (Semal et al., 2009; Flas, 2011). The presence of Middle and Upper Palaeolithic artifacts at Spy suggests that both Neanderthals and anatomically modern humans occupied the site, but Pleistocene human remains pertain only to Neanderthals (Semal et al., 2009). The faunal assemblages are dominated by remains of horse, cave hyena, mammoth, woolly rhino and cave bear (Germonpré et al., 2013). Some of the mammoth remains were

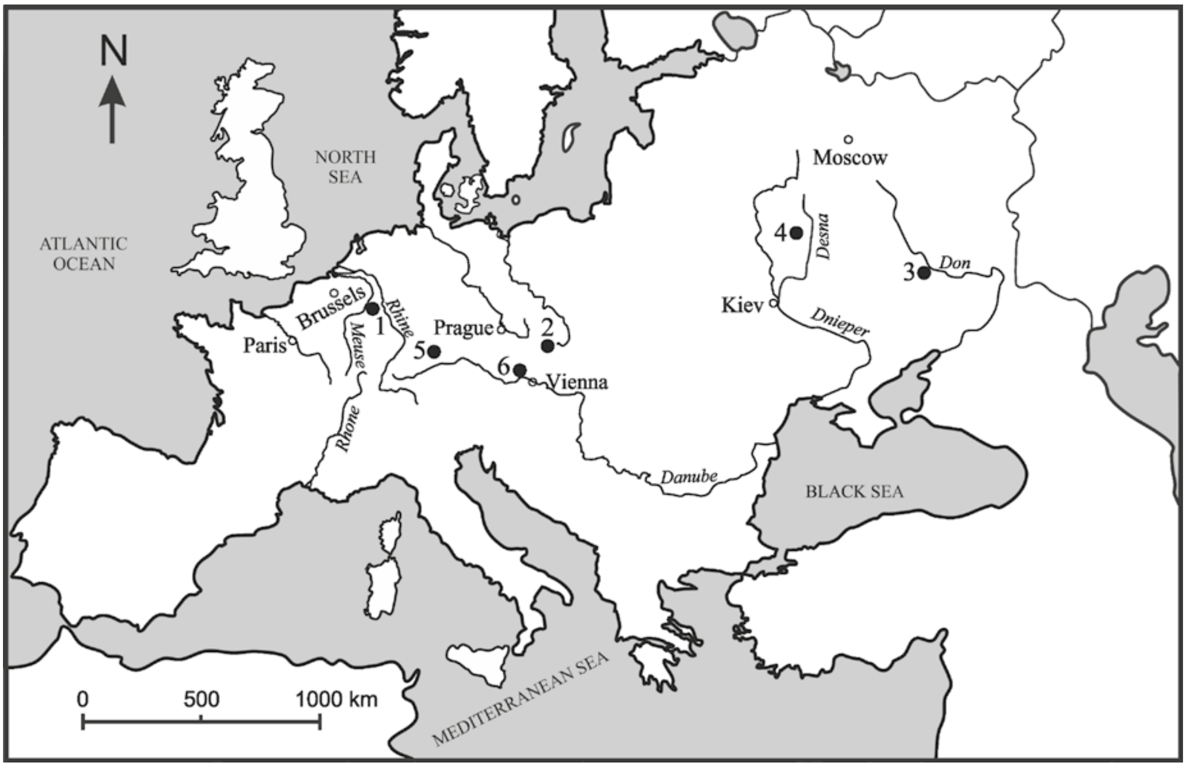

Figure 15.1: Map showing the most important sites discussed in the text. 1, Spy, Goyet; 2, Předmostí; 3, Kostěnki; 4, Yudinovo, Eliseevichi; 5, Geissenklösterle; 6, Krems-Wachtberg.

assigned to a fauna-bearing horizon also yielding Middle Palaeolithic lithics, the so-called "Deuxième niveau moustérien" ("Second Mousterian Level") (Germonpré et al., 2013, 2014). In addition, AMS dates are available for two mammoth DP3s. The younger AMS date (37,010 +440–380, GrA-37933) has a calibrated age range (95%, Oxcal 4.3) from 42,200 years BP to 40,800 years BP. The older AMS date (42,330 +500–450; GrA-32616) has a calibrated age range (Oxcal 3) from 46,600 years BP to 44,800 years BP. The calibrated ages of these deciduous teeth allow us to consider them as contemporaneous with the Middle Palaeolithic (Germonpré et al., 2013, 2014). In this study, all the mammoth deciduous premolars from Spy are grouped together. The stable isotope analyses of the collagen from two Neanderthal individuals from Spy reveal that mammoth was the most important prey species with a possible proportion of mammoth meat in their diet between 30% and 40% (Wißing et al., 2016).

15.3.2 GOYET

The third cave of Goyet (Belgium; Fig. 15.1) was excavated in the 19th and 20th century (Otte, 1979). It has an exceptionally rich archaeological, faunal and anthropological record, covering large periods from the Middle to the Upper Palaeolithic. It is the only site in the world, where human remains from populations dating from the Mousterian, Aurignacian, Gravettian and the Magdalenian have been found at the same location. In addition, a skull from a large canid has been described as being from a Palaeolithic dog (Germonpré et al., 2009, 2012). With a calibrated age of ~35,700 years BP, this canid would be the oldest domesticated animal known so far (Germonpré et al., 2009, 2018). However, this attribution is subject to controversy (Boudadi-Maligne and Escarguel, 2014; Morey, 2014; Drake et al., 2015; Janssens et al., 2016, 2019; but see Galeta et al., 2021). Dupont (1871) distinguished five bone-bearing horizons in the third cave of Goyet. He recovered numerous Pleistocene mammal bones, human remains, and large quantities of Middle and Upper Palaeolithic artifacts from these layers (Germonpré, 2001; Posth et al., 2016; Rougier et al., 2016). The dispersion of several AMS dates and the refitting of the human bones originating from different horizons, point out the mixed content of the horizons recognized by Dupont (Germonpré, 2001; Rougier et al., 2016). The faunal assemblages from the horizons are dominated by skeletal elements of reindeer, cave bear, cave hyena, horse and foxes (Germonpré, unpublished data). Here, the mammoth remains from the third cave of Goyet are grouped together, bearing in mind that they likely accumulated during an extended time span. The Goyet mammoth assemblage is less rich than that of Spy. This assemblage is dominated by ivory ornaments and fragments, likely dating from the Aurignacian and the Gravettian, several of which show ochre stains and cut marks (Germonpré, unpublished data). At Goyet, it seems that mammoth heads and, to a lesser extent, feet, were brought to the cave where the meat and fat could be consumed (Wißing et al., 2019a; Germonpré, unpublished data). Dietary reconstructions are available for several human individuals dating from the Middle Palaeolithic, Aurignacian and Gravettian assemblages (Wißing et al., 2016, 2019a, b). The results of the latter studies indicate that the diets of the analyzed Neanderthal individuals and those associated with Aurignacian assemblages included significant proportions of mammoth meat, whereas those associated with Gravettian assemblages relied more on horse and reindeer, and to a lesser extent on mammoth (Wißing et al., 2016, 2019a, b).

15.3.3 PŘEDMOSTÍ

Předmostí (Czech Republic; Fig. 15.1) is part of a series of large Gravettian open-air sites located in Central Europe, characterized by specific lithic tools (backed bladelets, geometric microliths, denticulated bladelets) (Polanská, 2018) and by the presence of human burials, mammoth remains, and ivory implements, ornaments, portable art, and animal and human female representations. Mammoths played an important role in the Central European societies of Gravettian hunter-gatherers (Svoboda, 2001; Oliva, 2007, 2009; Wojtal and Wilczyński, 2015), both in life (e.g., ivory tools, ivory portable art, ornaments) and in death (several human burials were covered by mammoth scapulae) (Valoch, 1981, 1982; Einwögerer et al., 2006; Svoboda, 2008; d'Errico et al., 2011; Lázničková-Galetová, 2016). At Předmostí, the mammal assemblage is dominated by mammoth. Musil (1958, 1968) examined in detail the mammoth teeth from this site. His descriptions and measurements of the deciduous premolars are used here to attribute an age to the very young calves (<12 months old). In all likelihood, mammoth formed the staple food for the Gravettian inhabitants from the site as can be deduced from the preponderance of mammoth in the faunal assemblage and the age distribution of the mammoth, dominated by young individuals (Absolon and Klíma, 1977; Oliva, 1997, Musil, 2008; Bosch, 2012). A recent study based on the analyses of stable isotopes showed that the proportional prey contribution of the mammoth to the human diet at this site amounted to ~40% (Bocherens et al., 2015). Large canids are the second most abundant group at Předmostí based on the MNI calculations (Pokorný, 1951; Musil, 2008), and include Pleistocene wolves and Palaeolithic dogs according to Germonpré et al. (2012, 2015). A new AMS analysis on a cut-marked femur of a large canid delivered a calibrated age range (95%) between 28,800 and 28,300 years BP (Germonpré et al., 2017).

15.3.4 KOSTËNKI-21

The site of Kostënki 21 (Russia) is located in the valley of the Don River at Kostënki (Voronezh Oblast, Russia) (Fig. 15.1). The main archaeological horizon, layer III, has a calibrated age of ~27,500–24,500 years BP and contained six com-

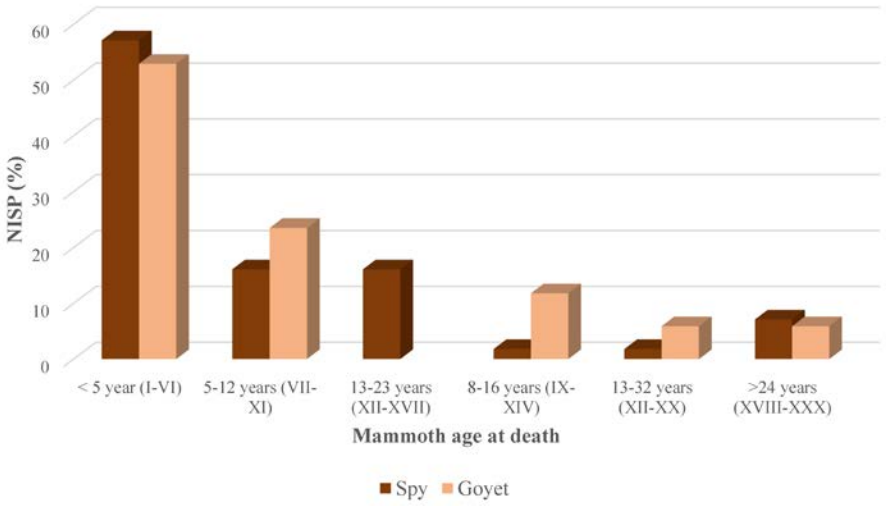

Figure 15.2: Age frequency distribution of all mammoth deciduous premolars from Spy and Goyet based on Laws' age groups (see text for details).

plexes of archaeological material with its lithic assemblages assigned to the Gravettian. The differences in the lithic typology and faunal assemblages of the six complexes permit their separation into two groups: a northern and a southern zone, which probably relate to separate phases of activity (Praslov and Ivanova, 1982; Praslov, 1985; Ivanova et al., 1987; Bessudnov, 2019; Reynolds et al., 2019). The mammal assemblage from the southern zone is dominated by mammoth remains, based on the MNI and NISP. The mammoth is the most abundant species in the northern zone based on the NISP. The diversity of the skeletal elements is much richer in the northern mammoth assemblage than in the southern one (Ivanova et al., 1987; Reynolds et al., 2019). An upper carnassial from a large canid found in the southern zone was described as dog-like in size (Reynolds et al., 2019).

15.3.5 YUDINOVO

The Epigravettian site Yudinovo (Russia) is situated on the right bank of the Sudost' River, a tributary of the Desna (Fig. 15.1). Dates for the main, lower layer suggest an age between 18,400 and 17,700 cal BP. Five complexes of mammoth skeletal elements characterize the site. Furthermore, large quantities of ivory hunting tools and ivory ornaments were recovered (Germonpré et al., 2008; Khlopachev, 2019; Sablin, 2019; Sablin et al., submitted). Details on the taphonomic and palaeobiological characteristics of two of these complexes can be found in Germonpré et al. (2008) and Germonpré and Sablin (2017), who proposed that the mammoth bones were harvested from hunted mammoths. The ontogenetic age distribution of the mammoth assemblage based on a combination of cranial and postcranial material is dominated by remains from young mammoths, less than 13 years old. However, remains from adult mammoths are also very well represented and most of this material probably pertains to cows (Germonpré et al., 2008). A humerus from a large canid was described as dog-like in size (Germonpré and Sablin, 2017).

15.4 RESULTS

15.4.1 SPY

Young nursing mammoth calves (Laws' age groups I–VI, <5 years old) are the most frequent class in the age distribution of the mammoth assemblage from Spy (Fig. 15.2, Table 15.2). The age distribution based on Laws' age groups (I, II, III, IV, V) in months, of the nursing calves is given in Table 15.2 and Figure 15.3. These results permit us to

Spy stratigraphy	Inventory number	Tooth	Jaw	Laws' age group	Age in months	P	Pa	L	W	H
-	17393	DP2	lower	I	0–1	5	0	16.2	15.1	10.3
-	-	DP2	upper	I	0–1	5	0	18.1	16.4	17.6
-	10261	DP2	lower	I	0–1	>3	0	>15	19.2	27.0
-	10621	DP2	upper	I	0–1	>3	0	>15	19.3	26.0
-	-	DP3	lower	II	2	8	3	52.6	34.2	-
-	1585	DP3	upper	II	2	8	4	56.9	30.8	40.1
- (AMS: 37,010 y BP)	5608	DP3	upper	II	2	8	4	58.4	37.0	39.7
-	16640	DP3	lower	III	3–6	8	5	52.9	28.1	33.2
Second level, Upper Mousterian	1038	DP3	lower	III	3–6	8	6	61.2	35.7	33.6
Cave	-	DP3	upper	III	3–6	9	5	60.8	35.6	35.3
Cave	1133	DP3	lower	IV	7	9	8	54.4	32.8	24.8
-	-	DP3	lower	IV	7	8	7	62.8	36.2	-
Second level, Upper Mousterian	-	DP3	lower	IV	7	8	7	53.1	31.3	37.2
Cave	-	DP3	?	IV	7	8	7	55.2	33.5	-
Second level, Upper Mousterian	1133	DP3	upper	IV	7	9	8	56.0	36.6	30.5
Second level, Upper Mousterian	-	DP3	upper	IV	7	8	7	52.8	30.6	34.6
Second level, Upper Mousterian	1585	DP3	upper	IV	7	10	9	57.7	33.6	40.0
Second level, Upper Mousterian	-	DP3	upper	IV	7	9	8	60.8	35.6	35.3
-	1133	DP3	upper	IV	7	8	8	57.3	34.1	36.0
Terrace	1133	DP3	upper	IV	7	8	8	56.0	36.6	30.5
-	-	DP4	upper	IV	7	14	6	96.8	49.8	73.0
Second level, Upper Mousterian	5608	DP3	lower	V	>12	8	8	61.9	36.6	28.0
Second level, Upper Mousterian	-	DP3	lower	V	>12	8	8	55.0	30.6	24.1
-	1133	DP3	lower	V	>12	8	8	57.5	33.9	34.5
-	1133	DP3	lower	V	>12	7	7	54.5	31.9	25.8
-	1133	DP3	lower	V	>12	7	7	54.3	31.7	24.9
-	B.1038	DP3	lower	V	>12	8	8	64.1	36,2	22.5
-	-	DP3	lower	V	>12	6	6	53.7	34.1	27.6
	1038	DP3	lower	V	>12	7	7	48.1	30.3	25.0
	16640	DP3	lower	II-V	3–>12	>6	>6	>43	31.5	30.6
- (AMS: 42,330 y BP)	19B-121-1474	DP3	?	II-V	3–>12	>4	?	34.3	-	-
Yellow earth	10261	DP3	lower	II-V	3–>12	>3	>3	>15	31.2	30.4

Spy stratigraphy	Inventory number	Tooth	Jaw	Laws' age group	Craig AEY in Haynes (1991: table A2)	P	Pa	L	W	H
-	-	DP4	lower	VII	5 y	12	12	102.1	53.5	10.1
Cave	158x	DP4	lower	VII	5 y	11	11	98.0	53.2	36.6
Terrace	-	DP4	lower	VII	5 y	9	9	81.2	43.6	17.1
-	-	DP4	lower	VII	5 y	10	10	79.5	53.5	27.2
-	-	DP4	lower	VII	5 y	5	5	70.7	59.5	-
Terrace	-	DP4	upper	VII	5 y	14	13	106.1	55.1	87.1

Table 15.2: List of all mammoth deciduous premolars from Spy, adapted and corrected from Germonpré et al. (2014), that can be assigned to a Laws' age group, ages in months and in AEY (African Equivalent Years); see text and Table 15.1 for details; P: number of plates, Pa: number of abraded plates, L: length, W: width, H: height.

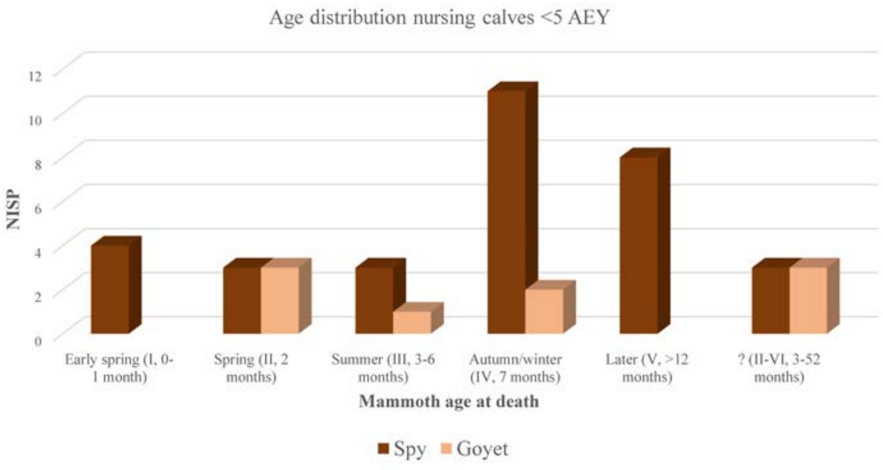

Figure 15.3: Age frequency distribution of mammoth deciduous premolars from Spy and Goyet based on Laws' age groups I up to VI (see text and Tables 15.1–15.3 for details).

GOYET STRATIGRAPHY	INVENTORY NUMBER	TOOTH	JAW	LAWS' AGE GROUP	AGE IN MONTHS	P	PA	L	W	H
A3	2777-6	DP2	upper	II	2	5	4	17.8	15.1	
A4	2860-4	DP3	lower	II	2	8	5	49.0	30.9	28.5
A3	2777-8	DP3	upper	II	2	8	3	63.5	34.0	37.9
A3	2777-10	DP4	upper	III	3–6	>7	3	65.0	50.6	70.6
A1	2815-10	DP3	upper	IV	7	6	6	47.0	37.2	12.8
A3	2777-9	DP3	lower	IV	7	8	8	54.2	34.4	21.8
A1	2815-13	DP4	lower	V	>12	8	5	>70	45.0	49.3
A3	2777-19	DP4	?	IV–VI	7–52	>1	0	-	39.3	52.9
A1	2815-11	DP4	upper	IV-VI	7–52	>3	2	-	43.0	64.0
GOYET STRATIGRAPHY	**INVENTORY NUMBER**	**TOOTH**	**JAW**	**LAWS' AGE GROUP**	**CRAIG AEY IN HAYNES (1991: TABLE A2)**	**P**	**PA**	**L**	**W**	**H**
A4	2860	DP4	upper	VII–VIII	5–7	>8	>8	55.5	47.9	67.8

Table 15.3: List of all mammoth deciduous premolars from Goyet, adapted and corrected from Wißing et al. (2019a), that can be assigned to a Laws' age group, ages in months and in AEY (African Equivalent Years); see text and Table 15.1 for details; P: number of plates, Pa: number of abraded plates, L: length, W: width, H: height.

conclude that mammoth calves died in the vicinity of Spy during all seasons.

15.4.2 GOYET

The age profile of the Goyet mammoth assemblage is dominated by young nursing calves (<5 years) (Fig. 15.2, Table 15.3). The Goyet mammoth assemblage contains a complete DP2. The wear of this tooth indicates that the animal died when it was ~2 months old (Laws' age group II). The wear of the other deciduous premolars, corresponding to Laws' age groups III, IV and V, suggests that mammoth calves also perished near the Goyet cave during spring, summer and autumn/winter (Fig. 15.3; Table 15.3).

15.4.3 PŘEDMOSTÍ

Young mammoths, 12 years old or younger, dominate the mammoth assemblage from Předmostí according to Bosch (2012). The age distribution of the

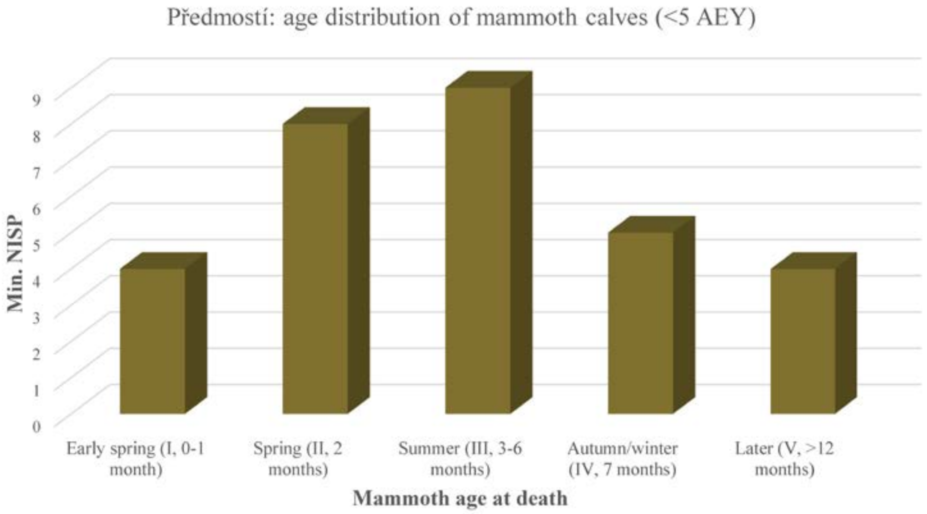

Figure 15.4: Age frequency distribution of mammoth deciduous premolars (DP2 NISP: 9; DP3 minimum NISP: 20) from Předmostí based on their description in Musil (1968); see text and Table 15.1 for details.

nursing mammoth calves from Předmostí is based on a minimum representation as deduced from the descriptions and figures in Musil (1968). Laws' age groups from I to V are represented among the dentition of juvenile mammoths (Fig. 15.4), suggesting that the calves died in every season.

15.4.4 KOSTËNKI-21

In the mammoth assemblage from the southern zone, four age groups can be distinguished with remains from foetal, juvenile, subadult and adult mammoths (Reynolds et al., 2019). The first age group consists of a cut-marked humerus from a mammoth foetus that died at a gestation age of about 14–16 months (Maschenko, 2002). The juvenile age group contains two deciduous tusks from a calf that probably died at an age of less than 4 months based on its minimal wear, two milk tusks from a calf that probably died when it was between 6 and 9 months old on the basis of more extensive wear, and another deciduous tusk that can be attributed to an age of ~1 year old on the basis of its extensive wear and a closed root canal. Furthermore, a complete DP2 with the first two plates showing wear can be attributed to an age of ~2 months. Another DP2 with all its plates in wear was likely from a mammoth calf that died between 4 and 8 months old (Maschenko, 2002; Reynolds et al., 2019). In the northern zone, a scapula of a mammoth calf is comparable in size to the scapula from Lyuba (Fisher et al., 2014: fig. 6); the Kostënki scapula could have been from a calf that had died, like the Lyuba calf (Rountrey et al., 2012), when it was between 1 and 2 months old (Reynolds et al., 2019). Furthermore, a lower jaw with a DP4, in which the first plates are in wear, is probably from a nursing calf with an age of ~3 years (Maschenko, 2002).

15.4.5 YUDINOVO

The age distribution of the cranial remains of the mammoths from this site is dominated by animals with ages older than 22 AEY (Germonpré et al., 2008). Juvenile remains consists of both cranial and postcranial material. Three dental elements and one maxillary fragment are from nursing calves younger than one year old. An isolated, maxillary DP2 with some wear (Laws' age group I) belonged to a 1-month old baby mammoth (Sablin, 2019). The stage of wear of a DP2 and a DP3 in a maxillary fragment, as described by Maschenko (2002), allow us to assign this specimen to Laws' age group III. An isolated DP3 has wear (cf. Maschenko, 2002) that corresponds to Laws' age group IV. A deciduous tusk pertains to a calf of about 6 to 9 months old (Maschenko, 2002). The young animals died during spring, summer and autumn or winter.

15.5 DISCUSSION

Mammoth hunting has been directly attested at several Upper Palaeolithic sites all over northern Eurasia. The oldest evidence has been found in an early Upper Palaeolithic layer at Kostënki-14 with a fragment from an ivory point embedded in a mammoth rib (Sinitsyn et al., 2019). The Gravettian site Krakow Spadzista (Poland) yielded a distal part of a mammoth rib with a pointed fragment of a flint implement embedded (Wojtal et al., 2019). The mammoth assemblage of the Gravettian site Kostënki-1/I contains a rib with an inserted flint point fragment (Praslov, 2000; Nuzhnyi et al., 2014). Further to the east, at the Late Glacial site Lugovskoye in Siberia, a mammoth thoracic vertebra was discovered with an embedded quartzite point (Zenin et al., 2006). In Yakutia, at the mid-Upper Palaeolithic Yana site, fragments of spear points in several mammoth scapulae testify to successful mammoth hunts (Nikolskiy et al., 2013). Also in Yakutia, at the Late Glacial site Nikita, a mammoth rib with embedded lithic fragments was found (Pitulko et al., 2016). All this direct evidence pertains to adult mammoths. Indirect evidence of mammoth hunting suggests that mammoth herds, composed of cows with their calves were also hunted (Fladerer, 2003; Germonpré et al., 2008, 2014; Münzel et al., 2017).

Human hunting of elephants often targets calves (Reshef and Barkai, 2015; Agam and Barkai, 2018). Possibly, the young age of the calves made the transport of their carcasses easier so that their skeletal remains had more chance to end up in the faunal assemblages found at settlements. Carcasses of hunted adults could have been left at the kill sites, with their meat only taken to the living site. Furthermore, there could have been nutritional advantages for the Palaeolithic hunters from the eating of meat of young, nursing elephants (better taste, specific nutrients, higher quality fat, e.g., omega-3 fatty acids related to the intake of cow's milk) (Germonpré et al., 2014; Guil-Guerrero et al., 2014; Reshef and Barkai, 2015; Agam and Barkai, 2016, 2018). Nevertheless, deliberate constructions and rich depositions of skeletal elements from adult mammoths have been found at many middle and late Upper Palaeolithic sites, especially in Central and Eastern Europe (Soffer, 1985; Pidoplichko, 1998; Svoboda et al., 2005, 2019; Oliva, 2007, 2009; Germonpré et al., 2008; Iakovleva, 2019; Sablin, 2019; Pryor et al., 2020; Sablin et al., submitted).

Below we compare our results with published data from the literature. Several published accounts, like the one from the Upper Palaeolithic site Boršice in the Czech Republic (Nývltová Fišáková et al., 2007), mention the presence of young mammoths, but here we focus on those articles that provide detailed descriptions of the deciduous premolars, which permit to deduce the season of death of the mammoth calves.

At the Belgian Spy and Goyet caves, nursing mammoth calves dominate the age profiles (Fig. 15.2). At Spy, it is very likely that several of these animals were killed and brought to the cave by Neanderthals as can be deduced from the fact that many of their remains were found in the "Second Mousterian Level" and that two premolars have calibrated ages in the time range of the Neanderthal presence in Belgium (Germonpré et al., 2013, 2014). It seems that the Neanderthals, which were occupying the site, went hunting for mammoths during all seasons (Fig. 15.3). In addition, analyses of the stable isotopes in the collagen from Neanderthal remains found at the cave show that the diets of these individuals contained significant proportions of mammoth meat (Wißing et al., 2016). At Goyet, nursing mammoth calves were probably hunted during spring, summer and autumn or winter (Fig. 15.3). For both the Neanderthal and early Upper Palaeolithic humans found at the Goyet cave, the mammoth was an important food source (Wißing et al., 2019a).

At Geissenklösterle cave (Germany), the Aurignacian layers contain dental remains from mammoth calves not older than 1 month when they died, indicating that mammoth hunting took place repeatedly in spring. The relatively good representation of the skeletal elements indicates that large portions of the calves' carcasses were brought to the cave where they were consumed, as attested by their cut-marked bones (Münzel et al., 2017).

At the Gravettian site Předmostí, the mammoth age profile is dominated by young individuals less than 12 AEY (Bosch, 2012). The detailed descriptions in Musil (1968) of the DP2 and DP3 permit us to infer that killed mammoth calves were brought to the site in all seasons, from early spring until winter (Fig. 15.4). This is in accordance with the idea of a year-round occupation of this major site, as also indicated by cementochronological studies (Nývltová Fišáková, 2013) and the extraordinary richness of the archaeological assemblage (Oliva, 1997). Furthermore, a recent study on the stable isotopes of the collagen of a human lower jaw from the site revealed that this individual ate frequently mammoth meat (Bocherens et al., 2015). Oliva (1997) proposed that this rich site, with its unique location near the Moravian Gate, functioned as an important gathering point, where humans from the region assembled for social contacts and ritual activities.

In both the northern and the southern zones of the Gravettian site Kostënki-21, the mammoth assemblages contain remains from mammoth calves that were still nursing at the time of their death. In the southern zone, mammoth calves were found that died when they were ~2 months old, between 4 and 9 months old and when they were ~1 year old (Maschenko, 2002; Reynolds et al., 2019). Furthermore, as conception probably took place in late spring (Rountrey et al., 2012; Grigoriev et al., 2017), the mammoth cow carrying a 14–16-month-old foetus likely died during spring/early summer. The above implies that during the occupation of the southern zone of Kostënki-21, mammoths were hunted during the spring and the beginning of the summer, and also at autumn and/or during winter. In the northern zone, a young calf died when it was about 1 to 2 months old, so it was probably hunted in spring. An older calf was killed at an age of ~3 years old, probably while it was still nursing (Reynolds et al., 2019). Interestingly, there is now also evidence for the killing of a nursing mammoth at the Gravettian Kostënki-9 site. The very elevated δ15N value (12.3 ‰) of a mammoth calf, that has an age of ~29,000–27,000 cal BP, suggests that it was still nursing when it was killed (Reynolds et al., in press).

At the Gravettian site Milovice (Czech Republic), several areas yielded remains from newborn mammoth calves that were hunted in early spring (Brugère and Fontana, 2009). In addition, dental cement microstructures from mammoth molars found in several sectors of the site indicates that a number of animals died during autumn (Nývltová Fišáková, 2013). The evidence of the same seasonalities in mammoth deaths in different sectors of the site suggests recurrent hunting patterns (Brugère and Fontana, 2009).

The faunal assemblage from the Gravettian Pavlov site I Southeast, also in the Czech Republic, is dominated by bones from canids (foxes and large canids), hare and reindeer. Nevertheless, mammoth was an important animal for the prehistoric people who occupied this location. The hunters skinned, dismembered and filleted mammoth carcasses as testified by the cut marks on several elements, suggesting that the mammoths were eaten, and that their bones and ivory were used to fabricate tools and ornaments (Wojtal and Wilczyński, 2015). Several mammoth teeth were discovered at the site, including unworn and worn DP2 and DP3 (Musil, 1959; Wojtal and Wilczyński, 2015), suggesting that the calves were killed during early spring, spring and summer.

At the nearby site Dolní Věstonice I, also dated to the Gravettian, the fauna is dominated by mammoth, but comprises also taxa like horse, large canids, reindeer and hare (Klíma, 1963; Svoboda et al., 2019). Here, several mammoth deciduous premolars were discovered, including unworn and worn DP2, pointing to mammoth hunting in early spring and spring (Klíma, 1963).

The living floor residue of the Gravettian open-air site of Krems-Wachtberg (Austria) corresponds probably to a single occupation episode. Remains from two adult mammoths, a cow and a bull, and from several subadult and juvenile mammoths, suggest that at least one mammoth herd was hunted (Fladerer, 2003). The attribution of the calf dental remains to Laws' age groups II and IV (Fladerer, 2003) makes an occupation during the winter months and spring likely.

At the Epigravettian site Yudinovo, the wear stages of the dentition (Laws' age groups I, III and IV) from the nursing mammoth calves suggest that they died during early spring, summer, and autumn and/or winter, and that the inhabitants of this site hunted mammoths during both warm and cold seasons.

The Epigravettian site Eliseevichi 1 is, like Yudinovo, located in the Desna valley (Russia). The faunal spectrum is mainly composed of woolly mammoth, reindeer, wolf and polar fox (Demay et al., 2019). Two canid skulls were previously described as those of Palaeolithic dogs (Sablin and Khlopachev, 2002; Germonpré et al., 2009). Cut marks on juvenile and adult bones of the mammoths indicate that the animals were skinned, disarticulated and defleshed. The dental remains of several mammoth calves allowed Demay et al. (2019) to assign them to Laws' age groups I–II and III. This suggests that the calves were killed during the spring and summer months.

From the short and non-exhaustive review above, we can conclude, based on the ontogenetic age attribution of the dentition of mammoth calves, that during the Middle and Upper Palaeolithic, mammoth hunting was not limited to the cold part of the year. This type of hunting could take place in all seasons. At some sites, the hunt was restricted to one or a few seasons, at other sites mammoth calves died year-round. It is possible that Palaeolithic hunters consumed fresh mammoth meat and fat at social gatherings and feasts that included not only people of their own settlements, but also those of neighboring groups (cf. Barkai, 2019; Lewis, this volume; Tanner, this volume), who were invited in order to share and consume as much meat as possible before it was spoiled, and to enjoy together the great abundance provided by the killing of the proboscidean (cf. Lewis, 2015, this volume; Tanner, this volume). Furthermore, the storage of mammoth meat and fat from animals killed during the warm half of the year must have involved other methods than freezing. Probably, the mammoth meat was also dried and/or smoked (see also Demay et al., this volume). Interestingly, isotopic investigations showed that the consumption of mammoth meat by small (polar fox, wolverine) or large (brown bear) predators was higher for individuals found where prehistoric humans ate a lot of mammoths, as in Předmostí, than at other sites (Bocherens et al., 2015). This suggests that some parts of the carcasses of mammoths hunted by the Upper Palaeolithic hunter-gatherers were also available to predators. Furthermore, it can be presumed that at the Upper Palaeolithic sites with evidence of mammoth hunting, Palaeolithic dogs would have been helpful to transport body parts of the hunted mammoths from the kill sites to the settlements and to protect the stored mammoth resources against plunderers (Germonpré et al., 2020). Remains from Palaeolithic dogs or large canids dog-like in size found at sites with mammoth assemblages have been described from the early Upper Palaeolithic in Western Europe (Goyet; Germonpré et al., 2009), from the middle Upper Palaeolithic in Central and Eastern Europa (Předmostí and several Kostënki sites; Germonpré et al. 2012, 2015; Germonpré and Sablin, 2017; Reynolds et al., 2019) and from the late Upper Palaeolithic in the Russian Plain (Mezin, Mezhirich, Eliseevichi, Yudinovo; Pidoplichko, 1998; Sablin and Khlopachev, 2002; Germonpré et al., 2009; Germonpré and Sablin, 2017).

Predation pressure on female mammoths and their calves by the Upper Palaeolithic hunters could have led to a population decline and opened the mammoth ecological niche to other herbivorous species, such as horses (Drucker et al., 2015). It may also have enabled the immigration of the Siberian clade of mammoths into Europe between 30,000 and 20,000 years ago (Palkopoulou et al., 2013; Fellows Yates et al., 2017). It appears that the ecological effects of mammoth hunting are visible for the Upper Palaeolithic, but not for the Middle Palaeolithic. This is possibly due to the higher intensity of hunting by modern humans compared to Neanderthals, perhaps related to the lower population density of the latter. This aspect is discussed in more detail by Bocherens and Drucker (this volume).

15.6 CONCLUSIONS

Combining all this evidence allows us to propose that nursing mammoth calves (and possibly their mothers) were killed and that their carcasses, heads or other body parts were transported to Middle and Upper Palaeolithic settlements by human hunters. The age at death of these calves implies that mammoth hunting took place during all seasons and was not limited to the cold part of the year. However, it must be pointed out that at Spy, Goyet and Předmostí, and likely at some other sites as well, the mammoth assemblages represent palimpsests and could reflect several hunting episodes (cf. Germonpré et al., 2014).

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16. UNDERWATER CARCASS STORAGE AND PROCESSING OF MARROW, BRAINS, AND DENTAL PULP: EVIDENCE FOR THE ROLE OF PROBOSCIDEANS IN HUMAN SUBSISTENCE

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ABSTRACT

Skeletal material of Late Pleistocene proboscideans in the North American Great Lakes region is often preserved in fine-grained, organic-rich sediment characteristic of small lakes and wetlands. Patterns of spatial distribution and articulation of bones often suggest that carcass parts were emplaced as multiple clusters of anatomically disparate butchery units, each including multiple bones. Clusters of skeletal material are sometimes associated with features that may have served as anchors intended to keep carcass parts tethered to a selected location within a pond, despite gas accumulation within soft tissues. One type of anchor consists of lithic material ranging from sand to gravel, where these sediments appear to have occupied a cylindrical container that was probably a length of intestine from the butchered animal. One site with well-documented "clastic anchors" also preserved two "marking posts" (an inverted main axis of spruce and an unidentified lateral axis) extending into sediment below the bone horizon but truncated by decomposition at the bone horizon. Each post probably extended to the pond surface at the time of emplacement and would have been visible from shore. These features suggest a practice of securing, concealing, and returning to utilize groups of nutritionally significant carcass parts stored underwater. Ethnographic parallels and rationales (extended time and reduced uncertainty of resource access) for this behavior are known, and experimental studies of subaqueous meat storage using deer heads, legs of lamb, and an adult draft horse show it to be effective over timescales ranging from months to years.

16.1 INTRODUCTION

In 1945 and for almost three decades thereafter, vertebrate palaeontology at the University of Michigan was represented mainly by Claude W. Hibbard. "Hibbie's" principal interests were in

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Pliocene–Pleistocene small-mammal faunas of the North American Great Plains, but like his predecessors, E. C. Case and (briefly) J. T. Gregory, he also dealt, somewhat reluctantly, with finds of Pleistocene megafauna encountered locally by farmers and excavators pursuing their normal activities. Most of these specimens were mastodons (*Mammut americanum*), but there were a few mammoths (often referred to *Mammuthus jeffersonii*). Looking back over almost 70 years of his unit's history, and a collection that then included over a hundred accessioned proboscideans, ranging in completeness from single teeth or bones to significant portions of skeletons, Hibbard observed late in his career (pers. comm., A. Holman August 1984; G. R. Smith October 2019) that hardly a year had passed without another report of a proboscidean from somewhere in the southern half of Michigan's Lower Peninsula. Most of these were in depressions on the late glacial landscape, typically in peat or marl that had formed in kettle lakes, small ponds, or wetlands. Exasperated at how often recovery of such specimens took him or his staff away from projects on the small mammal faunas he loved, he was heard on multiple occasions to "swear that there is a … mastodon in every … low spot in Michigan!" His colleagues never held his hyperbole (or his swearing) against him, as it seemed clear to most that many mastodons were simply unfortunate enough to have fallen through winter ice and become stuck or drowned in boggy areas or ponds. No mainstream vertebrate palaeontologist at the time anticipated issues that would have warranted mapping such specimens *in situ* or undertaking taphonomic analyses. Hibbard's work ethic was legendary, and his contributions to his field seminal, but mastodons were never his focus.

Fast-forward a few more years, and other young palaeontologists joined the University of Michigan faculty, again bringing with them interests that did not include mastodons, but within the first two months of employment for one of them, two more mastodons were reported, one of which presented such an unexpected suite of features that it catalyzed a growing curiosity. The Pleasant Lake site yielded bones (preserved in peat) with disarticulation marks, cutmarks, green-bone fracturing, use wear, impact features, and evidence of burning (12,576–11,841 calBP, calibrated years Before Present; Fisher, 1984a). These features were unexpected for an animal suspected of having died by accidental entrapment, and undergone disarticulation solely through processes of soft-tissue decomposition, without intervention from any external agent of disruption. Within a few more years (bringing another few mastodons; Fisher, 1984b), it began to seem that a number of these partial carcasses preserved traces of butchery activity by humans. However, even this unorthodox proposition did not fully explain the character of these occurrences. For one thing, their depositional settings were almost uniformly aquatic. The "bone horizon" within sediment sequences was typically well marked by the stratigraphic positions of medium-density elements, such as vertebrae, and where palaeo-depth could be estimated, it seemed that water on the order of 1–2 meters deep must have covered the pond bottoms on which those bones had lain. Surely, humans did not process carcasses underwater!

If humans had processed these carcasses, where and how had the butchery taken place, and how (and why) did carcass parts end up on pond bottoms? There might have been some point to throwing bones (from which meat had already been removed) into a pond, diminishing the odds that olfactory cues might attract scavengers intent on their own demands for trophic resources. However, many of the larger bones, not to mention sets of bones that retained anatomical associations, seemed too large to fit a model involving only casual disposal. What site formation processes could account for the character and complexity of much of our record of Pleistocene proboscideans?

At the request of symposium organizers, this paper is a retrospective account of the context and origin of a brief report introducing ideas on underwater meat storage (Fisher, 1995) and a preliminary review of more recent discoveries that bear on these ideas. I will also attempt to address issues that remain open and require new studies.

16.2 BIRTH OF AN IDEA

The Heisler mastodon site, in Calhoun County (south-central), Michigan, began as a modest investigation of a small number of bones discovered by a father-son farming team. They had been digging trenches to lay new, perforated plastic "tile line" through a low area on one of their fields, to replace the older system of cylindrical clay tile that had "silted-up" and no longer carried the water that often accumulated there, off to the edge of their field. The Heislers remembered encountering a few "big bones" when they had installed the old clay tile, and now more bones were turning up in the same depression. They finished laying their new tile lines but were curious enough to report their discovery. Initially accompanying Al Holman of Michigan State University and Ron Kapp of Alma College, the University of Michigan began to explore this site as thoroughly as possible. The Heisler's operation was large enough that they were able to let us attempt to recover more of this animal, as long as we backfilled our excavation as we went, limiting our impact at any given time. Most such sites had been dealt with quickly, as palaeontological salvage operations, but the Heisler site offered an opportunity for a different approach.

Over the next eleven years (1984–1994), working mostly on weekends, spring through autumn, with a few student helpers and a small but dedicated crew from the Huron Valley Chapter of the Michigan Archaeological Society, we excavated much of the Late Pleistocene pond that underlay this low area on the Heisler farm. In doing so, we recovered over 50% of the skeleton of a male mastodon, about 16 years old at death. The largest surprise of the early phases of this work was that the parts of this animal were not in just one area of the pond. Instead, they were in multiple areas within the pond. The animal was preserved mostly as diffuse scatters of disarticulated bones, separated from other such scatters. However, there was one discrete concentration, much smaller in area than the diffuse scatters. This locus preserved bones of what appeared to have been three body parts, all within an area less than a meter across. Each part was represented by a suite of anatomically contiguous bones, still associated, but most no longer articulated. Figure 16.1 shows one of these units (right ribs 1–4) as it would have appeared after removal from the carcass. Can we rule out transport of each rib to the pond independently? Perhaps not, but interpreting them as having moved as a unit is a more parsimonious explanation for their joint presence at one location. As such, they probably arrived at the pond, held together only by associated soft tissues, because neither the intervening thoracic vertebrae nor the sternebrae that would have connected them in life were present in the cluster. The other bones in this cluster were a sequence of cervical vertebrae and a sequence of thoracic vertebrae from just behind right ribs 1–4. Following the same reasoning as before, these suites of bones were probably also transported as units. However, given the limited soft-tissue connections between two noncontiguous segments of axial skeleton and an intervening slab of four ribs and associated tissue, this cluster is unlikely to represent fewer than three units.

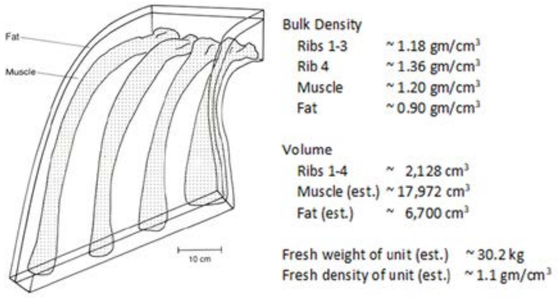

Figure 16.1: Schematic drawing of right ribs 1–4 of the Heisler mastodon (UM 61888), as they might have appeared as a freshly extracted butchery unit, surrounded by soft tissue at the time of emplacement in the pond where parts of the carcass of this animal were stored. Tissue volume and density estimates permit rough calculation of the fresh weight (~30.2 kg) and bulk density (~1.1 gm/cm^3) of this butchery unit.

The diagram in Figure 16.1 was prepared decades ago (Fisher, 1989) and is re-used here to show the history of the idea rather than to defend details of the physical model it summarizes. Knowing more about proboscidean osteology than I did then, I would now draw the ventral ends of these ribs closer together, reducing the implied volume of intercostal musculature and better representing the imbricate relationships of ribs in the lateral wall of the anterior portion of the proboscidean thorax. In other ways as well, I may have over-estimated the volume of soft tissue associated with this carcass unit, and I never meant the partitioning of muscle and fat to be anything more than a graphic approach to placing reasonable constraints on the fresh mass and bulk density of this unit. Even allowing for some reduction of soft tissue volume, this is not a carcass part that could have been tossed casually from the shore of the pond to its resting place. Once submerged in pond water, this unit would likely have been negatively buoyant, remaining at least initially on the pond bottom, but why and how did it get there in the first place?

Not far from the concentration of carcass parts described above was another surprise, a vertically oriented main axis of spruce (*Picea* sp.), about 10 cm in diameter at its upper end (Fig. 16.2), where it was truncated by decomposition, at the local level of the bone horizon, about a meter below the surface. From here, the main axis extended about 80 cm further into underlying sediment. Tracing the trunk downward while it was still *in situ*, its diameter got smaller, and its side branches all angled outward and down, showing that the apex of the main axis was lowermost. Overall, wood was not common in the pond sediments, but it did often occur in association with bones of the mastodon. In these cases, it was typically unburned branches of spruce (although some partially burned branches were also found), and it almost always lay parallel to bedding. In only one other instance, located near a diffuse scatter of bones in the pond, did we find wood (in this case a lateral axis) oriented vertically. What mechanism apart from human activity could account for this orientation?

Figure 16.2: Oblique view of vertically embedded spruce main axis in lacustrine marl at the Heisler mastodon site. Upper end of axis is truncated by decomposition at the stratigraphic level of the main bone horizon. This feature is interpreted as a "marking post" that would have originally been visible from shore, indicating the location of stored carcass parts within the pond. Lower margin of chalkboard provides scale (cm).

Perhaps the strangest type of feature at the Heisler site was again associated with concentrations of carcass parts, but explaining its discovery requires describing our excavation methods. We realized that this site might be extensive and that we needed methods that permitted recovery of small items, while also allowing us to finish the job before our careers ended. Our approach involved five modes of processing sediment:

1. Reconnaissance: For our first pass over a given portion of the site, we used stainless steel probes about 2 meters long, inserted into the surface of the field on a hexagonal pattern at ca. 15–20 cm spacing. This gave us advance warning of large bones, although it only occasionally registered small bones.
2. Coarse recovery: Our standard approach for excavation was a technique we called peeling—forcing a shovel blade horizontally through sediment 2–5 cm below the current surface. This cut through sediment and risked marking a bone, but by listening closely and gauging resistance, we avoided excessive damage.
3. Fine recovery: This was typical use of trowels to slice sediment horizontally, again using all senses to avoid damage to specimens, shifting to use of bamboo or other wooden probes to protect bone surfaces.
4. Delicate recovery: In the immediate vicinity of specimens that were difficult to understand from visual cues, we defaulted to using only bare fingertips and small wooden probes.
5. Bulk recovery: To preserve complex relation-

ships, we undercut and removed blocks of sediment, returning them to the lab for archiving or for dissection under more controled conditions.

The feature illustrated in Figure 16.3 was discovered while peeling down from the surface. Below the plow zone was a peat stratum that extended throughout the pond basin. This peat consistently displayed a hexagonal pattern of desiccation features that provided visual confirmation that the stratigraphic sequence was locally intact. All penetrations of the peat stratum, such as the Heislers' tile-line trenches, were immediately recognizable by their truncation of both the peat and its desiccation features. A pollen analysis by Bearss and Kapp (1987) established that the peat was early Holocene in age, and the desiccation was probably mid-Holocene. Underlying the peat was a marl sequence, the uppermost portion of which generally preserved the lower ends of desiccation fractures passing through the peat and in-filled with dark muck soil from above the peat. The bone horizon was within the marl sequence and typically below desiccation features (except near the pond margin). As noted above, it was usually about a meter below the surface, but it deepened toward the pond center and rose toward the pond margin. A normal array of desiccation features was present in this location.

Approaching the bone horizon in the area shown in Figure 16.3, we reduced peeling depth to 2–3 cm. On one peeled surface (level #1 in Fig. 16.3C), only marl was exposed, but just 3 cm below this, the shovel's motion produced the

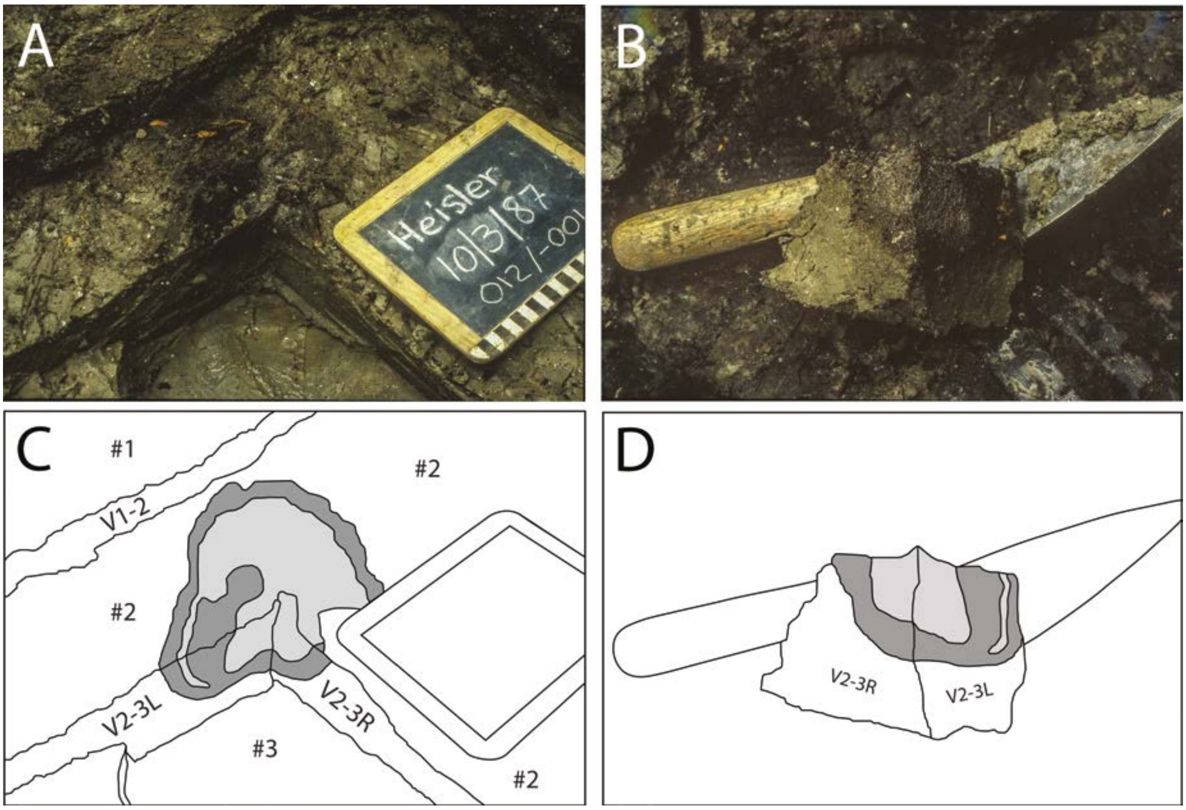

Figure 16.3: *In situ* "clastic anchor" at the Heisler mastodon site. **A,** lower margin of chalkboard shows scale (cm); chalkboard lists site data. **B,** quadrant of "clastic anchor" resting against trowel (28 cm total length) after removal from foreground in A. **C,** interpretive diagram of image in A. Numbered surfaces represent successive stratigraphic levels: #1, just above level at which feature appeared; #2, surface at which feature appeared, minimally cleared; #3, level below feature, accessed to remove quadrant shown in B. V1-2, vertical surface between levels #1 and #2; V2-3L, vertical surface between levels #2 and #3, exposure left of quadrant corner; V2-3R, as before, but right of quadrant corner. Dark gray tone, zone of brown plant material surrounding feature; light gray tone, feature interior of sand, gravel, charcoal, and wood fragments. **D,** tracing of quadrant removed in B. Graphical symbols as in C, but vertical surfaces R and L reversed because of rotation of quadrant.

scraping sound of steel-on-sand. Switching to a trowel, a roughly horizontal surface just below this was minimally cleared, revealing a roughly oval area of dark brown to black finely-ground plant material, light gray sand, scattered gravel clasts, and fragments of wood and charcoal, all surrounded by undisturbed marl (level #2 in Fig. 16.3C). A schematic diagram of a horizontal section (just below level #2, with major and minor diameters of 35 and 25 cm) through the feature was published in Rhodes et al. (1998: fig. 1). Additional details are provided in Figures 16.3C and D, showing two vertical sections and a third, horizontal slice (level #3) cut with the trowel to remove one quadrant of the feature (Fig. 16.3D). Based on the profiles revealed there, the mass as a whole had the form of the lower hemisphere of what might originally have been an ovoid object sitting on the ancient pond bottom, nestled into soft marl. This interpretation was corroborated by removal of additional sections of the structure, after which the whole feature was returned to the lab for dissection and archiving.

Our field observations showed that this feature was isolated from any other source of sand or gravel or any accumulation of plant material within the local stratigraphic section. The contact between marl and the peripheral zone of plant material was sharp, with no evident mixing of these materials. The zone of plant material was in most places 1–2 cm thick around the entire downward-facing surface of the hemisphere. Its boundary with the generally inorganic interior of the mass was more irregular, or even gradational. One complication of this contact was a lobe of plant material that was darker in color (varying from brown to black, with included charcoal) and extended into the space otherwise occupied by sand (left side of feature in Fig. 16.3C).

Even after observing the geometry of this feature, we had no more than a hunch as to how it could have originated, what accounted for its internal zonation, or what had happened to the upper hemisphere of this putatively ovoid mass. The part of the problem that seemed most tractable was the nature of the brown zone of plant material. I recalled published accounts of intestinal material encountered during mastodon excavations (e.g., Dreimanis, 1968), but in such cases the plant material was coarser, and it was not associated with sand or gravel. Because Ron Kapp had recently done a palynological study of the Heisler site (Bearss and Kapp, 1987), I asked if he would analyze a sample of the marl immediately outside the hemispherical mass to compare its pollen content with that of a sample from the zone of brown plant material around the periphery of the mass. As recounted in Birks et al. (2019), the marl yielded the same pollen profile documented by Bearss and Kapp (1987), representing the year-round pollen rain that had accumulated elsewhere within pond sediments. However, in the peripheral brown zone, Ron found only pollen produced in late summer and autumn. Spruce pollen, which forms and disperses in spring and had been common in the marl, was conspicuously absent.

By the time I heard this report, I had made and analyzed a thin section from the proximal end of the Heisler mastodon’s left tusk, which we had found (out of its alveolus) with another scatter of material, not associated with the skull. The season of death (deduced from analysis of the last-formed incremental features of tusk dentin) was autumn (Fisher, 1987), consistent with Ron’s pollen analysis. This strengthened the “hunch” mentioned above, to the point that I dared formulate a more complete hypothesis for the nature of the feature in Figure 16.3. The peripheral zone of plant material probably reflected chewed and partly digested contents adhering to the inner wall of a piece of the Heisler mastodon’s large intestine. The autumn pollen profile of this material would be expected in vegetation of the season, ingested shortly before death. The sand and other material filling the lumen of the intestine was unexpected, but could have been introduced by humans to transform a short length of intestine (from which most of the normal contents had been removed) into a moderately dense container that might function as an anchor. Assuming we learn why humans were interested in making an anchor, an issue to which we return below, the "lower hemisphere" we recovered could have been simply the portion of the original anchor that was preserved because it settled into the soft, anoxic setting of marl on the pond bottom. The upper hemisphere of the anchor would have protruded into better-oxygenated water above the pond bottom, where it would have been subject to scavenging by frogs, fish, and possibly turtles, allowing its confining intestinal tissue to disintegrate, and the upper half of its contents to disperse before additional sedimentation could protect that part of the anchor. The intestinal tissue confining the lower half would have disintegrated as well, but this simply juxtaposed, without mixing, the anchor contents and surrounding marl. A final footnote on this interpretation is that the lobe of dark plant material extending into the sand on the left side of the feature in Figure 16.3A and C could reflect miscellaneous contents compressed between intestinal walls pulled into an overhand knot used to secure one end of the length of intestine. How the other end was secured, or even how long the anchor was originally, is unknown.

In full disclosure, a recent attempt to improve knowledge of plant remains from intestinal contents of the Heisler mastodon produced results that conflict with the above account (Birks et al., 2019). A different sample, from a second anchor-like feature at the Heisler site yielded pollen characteristic of spring rather than autumn. Unfortunately, revisiting Ron Kapp's analysis was not an option. Several years after he notified me of his finding (pers. comm., R. Kapp December 1987) he was diagnosed with a brain tumor, from which he succumbed before he could publish his work. Attempts to follow up with his family and a collaborator yielded no new documentation. Birks et al. (2019) discuss three possible reasons for the different outcomes of their analysis and prior analyses, but at this time, this problem remains unresolved. Overall, the Heisler site yielded two other anchor-like features that were similar in character, and a fourth was probably present as well. One of our volunteers, after witnessing the attention focused on the feature in Figure 16.3, commented that he "probably should mention" that an hour or so earlier, while working in another locus, he had encountered something "like that one, except made only of gravel." Not realizing its potential significance, he had shovelled through it.

Before continuing, we should return to the skull, mentioned briefly above. The mandible was no longer part of the same unit; it was found elsewhere at the site and more than a meter deeper in the sediment, where it had settled through the entire marl sequence until its dense cortical bone reached hydraulic equilibrium with underlying silty clay. As noted above, the left tusk had been removed, but the right tusk was still inside its alveolus and had been rotated forcefully until it jammed. The palate and basicranium are the densest parts of the skull, and with the mandible out of the way and the rotated right tusk extending roughly parallel to the pond bottom, the left side of the basicranium had settled more deeply into the marl. This meant that the dorsal aspect of the skull roof was inclined laterally. On removing sediment from the skull roof, we saw an array of gouges (cleaned out only with a gentle spray of water) that could all have been made by the same object (Fisher, 1987) perhaps while removing hide, or a layer of subcutaneous fat, from the skull roof. Another instance of minor damage was that one of the unfused exoccipitals had been removed, transforming the foramen magnum into a larger opening through which one hand of an adult human could have just fit, allowing access to the brain.

Brief descriptions of the Heisler site have been included in several previous publications (e.g., Fisher, 1987, 1995, 2009), but the site as a whole has not yet been described. Multiple dates are available, most notably, an AMS date on bone collagen (XAD-purified gelatin hydrolysate), returning a calibrated age of 13,825–13,361 calBP and an AMS date on plant material in the anchor-like feature in Figure 16.3, yielding a range of 13,476–13,009 calBP (Birks et al., 2019). What remains to discuss here, before moving to other sites and issues, is how the observations above influence a developing model of site formation processes. First, why would carcass parts like the one represented by right ribs 1–4 have been brought from a mastodon death and butchery site and deposited in a pond? We need not be unduly concerned about how far such parts were transported. The post-glacial landscape of this region was dotted with similar ponds, so if stashing carcass parts in ponds was normal practice, a pond might have been found near almost anywhere a mastodon might have died. The two vertical posts suggest that deposition of carcass parts in ponds was not just a matter of disposal. Time and energy would have been required to install such posts. If the posts were installed in autumn, the time of death supported by tusk analysis, the simplest method would be for someone to swim with a post to the selected location in the pond, point the post's smaller end downward into the marl, and thrust it deeper in several abrupt, inertial movements. The upper ends of posts would have initially projected above the air-water interface and could have been used as visual cues to return to and retrieve carcass parts on the pond bottom. In time, the wood immersed in oxygenated pond water decomposed, while the portion of each post embedded in marl was preserved. This suggests that the carcass parts that were brought to and deposited in the pond would remain a valuable resource for some time. Is this really a viable strategy for meat storage? Over what time interval would it operate, and what other costs and benefits might emerge? The density calculation for the carcass part associated with right ribs did not suggest it would require any type of anchor during its early phase of storage, but carcass parts with a larger fraction of fat might be different in this regard. It quickly became clear that parts of this problem would be difficult to resolve without turning to a more experimental approach, which I discuss below.

On the other hand, parts of the problem might be explored as "thought experiments." If nothing else, these might clarify questions that should be formulated explicitly in hope that new data might bear on them. For example, why were carcass parts deposited in multiple locations in a pond, each separated from others by some distance? I have not yet shown this directly because completing a general map of the Heisler site is a task requiring more time than is available for this paper, but my impression is that the Heisler site involved at least six locations in the pond. At one end of a spectrum of patterns of element distribution, we have the dense concentration including right ribs 1–4. These were apparently deposited, but never retrieved or utilized. At the other end of the spectrum are larger groups of carcass parts that were apparently retrieved and utilized, but not in a way that removed them from the pond setting. Some of these bones show marks suggesting tissue removal, and were found scattered in the pond—the "diffuse scatters" noted above. However, distinguishing "diffuse scatters" from each other is a statistical problem requiring a quantitative approach. Some utilization of stored parts could have occurred in a season, and in a manner (e.g., retrieving parts in winter, through a hole in ice, followed by dragging parts onshore) that would have removed bones from the pond setting. This could be one explanation for parts of the carcass we did not recover.

In general, multiple locations for a stored resource suggests a strategy of risk reduction—that leaving the entire resource in one location might somehow raise the odds of losing it to a competitor. Was that competitor a non-human scavenger? Or was it one or more other human occupants of the region? The former category might have included now-extinct taxa such as the short-faced bear (*Arctodus simus*), about whose behavior we know relatively little. On the other hand, human ingenuity might be even more likely to short circuit the "marking post" strategy used at least twice at the Heisler site, so whether that behavioral element was used rarely or routinely may have implications for the agency of competition. Even more broadly, risk reduction in the context of managing nutritional resources speaks to the reality of the prospect of at least seasonal nutritional stress for humans in Late Pleistocene North America, and it highlights the important role that proboscideans may have played in human subsistence.

One topic I intend to leave largely "on the side" in this discussion is the matter of resource acquisition. This is not because I view the issue as unimportant. It is rather because I have addressed the issue previously and would prefer here to focus here on different questions. I still regard Fisher (1987) as a source of data and probabilistic arguments favoring the idea that a significant number of Late Pleistocene mastodons in the Great Lakes region of North America were more likely hunted than scavenged. This applies especially to those that show evidence of butchery, that were male, that died relatively young, and that turn out to have died in autumn. The most significant expansion of this interpretation was proposed in Fisher (2009) and came about mainly because of discoveries at sites that had not been considered previously. One new site category yielded mainly crania, some of which were male and some female, some of which were found in almost perfect condition and others that preserve little more than the palate and basicranium (Barondess, 1996). I suspect these were mostly natural deaths on which little externally accessible tissue remained, but they were evidently procured and considered worth storing in ponds for later recovery and extraction of brain and nasal mucosa, as first represented by the St. Johns mastodon (Fisher, 2009). The second newly recognized phenomenon involved adult males that had died in late spring or early summer, as victims of musth conflict. These individuals seem to have died during their own reproductive quest, after which some were apparently scavenged by humans.

A final set of questions that already demand answers concerns the logistics of bringing carcass parts to the pond, installing them underwater, and retrieving them for later use. One of the goals of strategic disarticulation in the earliest stages of butchery would be to reduce the original carcass to manageable units. What is "manageable" depends mostly on how many people are involved, leavened with a little ingenuity. Numerous transport options exist, like dragging a piece of hide loaded with carcass parts, and if snow had fallen, the task only becomes easier. Even without snow, a makeshift travois would reduce friction while still supporting much of the weight through contact with the ground. However engineered, large portions of a mastodon, including its skull, mandible and tusks (even if it was a young individual), did end up in pieces on the bottom of a pond.

As for how humans installed carcass parts in ponds, autumn death suggests that a frozen pond was not required. The single largest element being installed was the skull and tusks, and although a fresh skull is heavy, the extensive system of paranasal sinuses in proboscidean skulls makes them float readily (Frison and Todd, 1986). The problem is thus not how to move a skull to the "right place" in a pond (swimming alongside it will do), but how to sink it when you get there. The answer to this is likewise direct—simply puncture the thin cortical bone of the cranial roof to allow air to escape and permit water to flood the sinus system. The skull roof of the Heisler mastodon has several such holes, leaving only the question of which were made when sinking it and which were made later, at the time of recovery and further processing. Other carcass parts would not have been so accommodating, but neither was their bulk density great enough to pose insurmountable problems. I suspect that buoyancy was again an ally. A dead proboscidean is more than a massive nutritional resource. It also yields tissues and materials suitable for use in various stages of processing. Lengths of intestine could have been removed and most of their contents discarded. Humans could then tie off one end, inflate the intestine with air, tie off the other end, and bend the inflated column around to circumscribe a larger area. Lashing this circular bladder together and adding strips of rawhide across the center would provide support to several carcass parts while ferrying them to their drop-off spot. The most effective approach for this would be to let carcass parts "ride low" in the water so that most of their mass was buoyed by displaced pond water. All that had to be supported by floatation was the fraction of a gram per cubic centimeter by which the density of the fresh carcass part exceeded that of water. Where appropriate, an anchor could likewise have been delivered, with a tether of rawhide connecting it to carcass parts in need of its service.

And lastly, how would these parts have been retrieved and utilized? The task might be easiest if the pond was frozen in winter. Even a nondescript chopper made of bone or stone would have sufficed to start a hole in ice, which could then be enlarged (not to mention the sunlit-boulder option summarized in Fisher, 1995). By choosing the spot with reference to the emergent upper end of a marking post, and remembering the deployment of parts on the pond bottom, one could in principle make a prior selection of carcass parts to retrieve. If parts had been installed in pairs or triplets, tied together with moderate lengths of rawhide, a "snagging pole" not much longer than two meters, with a "hook" fashioned from a side branch, could be lowered through the hole in the ice and swept across the marl bottom to snag a rawhide tether and pull two or three carcass parts to the surface. Once up on the ice, an assistant might remove meat from the bone while the "snagger" reprised their role. If exposure to cold or developing hunger became an issue, a fire might be started on the ice, to warm cold hands and prepare retrieved meat and fat. Leaving the pond when the job was done, unused fire-wood, along with wood that was partly burned, would be left on the ice, along with bones now separated from their cover of meat. By spring, all would return to the pond bottom, as we found them. And what if no ice was present when hunger brought people back to the pond? Planning and anticipation are as critical for survival as making the right decision under pressure. By deflating the intestinal flotation bladder and anchoring it under a rock in shallow water, it could be retrieved, re-inflated, and used again for ferrying carcass parts from storage locations to shore. The job of retrieval would again require swimming (unless a small boat were devised), and the swimmer would likely become thoroughly chilled. The fire might need to be larger and would be located onshore. Bones might then be abandoned onshore as well and if so, would probably never be preserved. Skeptics may consider this exercise in imagination futile and ultimately untestable, but this misses my intent. I am under no illusion that these ideas probe the full range of possibilities, let alone reveal the best. My goal in this exercise is rather to confirm that some plausible sequence of behaviors exists that would allow the core activity of underwater preservation of carcass parts to be implemented. Without such assurance, an elaborate program of experiments to test the efficacy of underwater meat preservation would be unwarranted.

16.3 A REPLICATE CASE?

In December 1989, my teaching duties had just wrapped up for the semester, and we had secured the Heisler site for the winter, with plans to return next spring, when I was contacted by Brad Lepper of the Ohio Historical Society. Brad told me of a recently discovered mastodon in Licking County, in central Ohio. The mastodon had been found by a dragline operator removing peat from a Late Pleistocene kettle lake basin to create a water feature for the Burning Tree Golf Course, then being expanded. On short notice, Brad and Paul Hooge of the Licking County Archaeology and Landmarks Society (along with a number of volunteers) had been invited to extract the mastodon skeleton. Both archaeologists were well trained for working in cultural contexts, but both assumed that this was going to be just another of those well-known cases where a mastodon had become mired in peaty sediment or fallen through ice and drowned. The schedule would be too tight for them to follow standard archaeological procedures for documenting the site, but the opportunity still seemed potentially informative. Initially, they were given only one day to recover the skeleton, but with below-freezing temperatures and severe wind chill, the landowner relented and gave them a second day. There was at least some time to snap photos of bones from various angles, but they mostly pressed ahead through long days in the harsh weather, pulling bones from the peat and shuttling them to safety. By the time Brad called me, the site was closed, and the bones had been moved to a quickly organized field lab. His invitation was simply for me to come help them identify what bones had been recovered and decide how best to handle their conservation, especially since they seemed unusually well preserved.

Upon arrival in Licking County, I was struck first by the excellent condition of the specimen. It was a mature male, large even for its age (as judged from its molar dentition, its tusks, and its degree of epiphysis fusion), and significantly more complete than the Heisler mastodon with which I had become familiar. We would later determine that this animal was about 33 years old at death. While sorting and identifying bones, Brad and I enjoyed a running conversation, with me peppering him with questions about the overall character and organization of the Burning Tree site, and him plying me with requests for comparisons with other sites I had observed. One of the first impressions to emerge was that the Burning Tree bones had not been distributed randomly over the site. The dragline operator had stopped work shortly after striking the posterior aspect of the skull with his bucket, so the site was barely disturbed when Brad and Paul had been introduced to it. Yet the bones already beginning to be exposed were closely juxtaposed, some overlying others. In fact, it did not take an osteologist to recognize the anatomical incongruence of the parts assembled there. The skull and tusks were at the bottom of the pile, although the cranium projected higher and was already partly exposed. Sprawled across the tusks was the massive pelvis. Nearby, but not articulated, was the only femur recovered, and elsewhere in the pile were both scapulae, each essentially complete, but with similar damage to their spinous process and along their vertebral and posterior margins. Other aspects of site configuration are best communicated by Figure 16.4. Except for one feature added here, this is only a modestly updated version of the site diagram published in Fisher et al. (1994: fig. 3.4). I refer to it as a "diagram" rather than a "map" because spatial relationships were not directly measured *in situ*, but were reconstructed by consulting all photos from the recovery operation, identifying all bones that were clearly enough exposed in these, and triangulating to estimate their relative locations. This was a joint activity in which we retained only elements on which direct participants agreed. For example, we know both scapulae were associated with the skull and pelvis, but no photo turned up in which they were visible. Participants were unanimous that all bones not recovered in the "skull cluster" were found in one of two additional clusters located meters from each other and from the skull. In Fisher et al. (1994) this diagram was accompanied by an osteological diagram (fig. 3.2) in which bones were given overlay patterns attributing them to one of five categories. Bones were either recognized as derived from one of the three clusters, left in a category of unknown cluster affiliation, or grouped as bones not recovered. The second and third clusters both contained bones that were articulated as in life, along with others that were disarticulated. Occurrence of the Burning Tree bones in fibrous peat may explain the more complete retention of articular relationships than was typical for Heisler

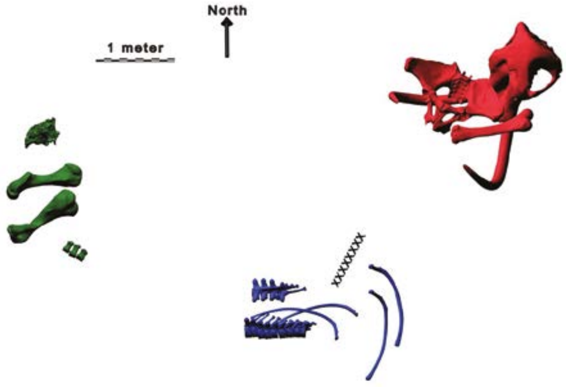

Figure 16.4: Relative locations and positions of bones of the Burning Tree mastodon, reconstructed from photos taken during the recovery operation. This diagram is updated from Fisher et al. (1994: fig. 3.4), most notably by inclusion of an array of x's showing the relative location of a cylindrical mass of intestinal material (pers. comm., B. Lepper February 2020). The green cluster (in addition to both humeri) includes an articulated series of cervical vertebrae (not including the first, or atlas vertebra) and articulated metacarpals, and the blue cluster includes two sequences of articulated thoracic vertebrae, in addition to four disarticulated ribs.

bones, all of which occurred in marl. Still, the overall configuration of both sites was similar.

Most new elements of Figure 16.4 are essentially cosmetic. Older line drawings of bones are swapped for rendered 3D models of bones, not from the Burning Tree mastodon itself, but from a specimen that emerged later on our timeline. Clusters are here given signature colors, coordinating with a color version of the osteological diagram not included here. However, a substantive new element is the array of x's showing the approximate location of a cylindrical mass of plant material recognized by Lepper while working near the articulated thoracic vertebrae of the "blue cluster." This mass was "(ca. 60 × 12 cm) distinguished from the surrounding dark brown peat by its reddish-brown color and pungent odor" (Lepper et al., 1991: p. 122). Even in the rush of recovery, this was provisionally identified as intestinal contents, and later work confirmed that its botanical remains were distinct from those of surrounding peat (Lepper et al., 1991; Birks et al., 2019). However, no trace of sand or gravel was present.

Observations and inferences concerning the Burning Tree mastodon add new support for the idea that humans were agents of postmortem bone modification and transport at this site (Fisher et al., 1994). When dates became available, they were no great surprise. An AMS date on bone collagen (XAD-purified gelatin hydrolysate) yielded a calibrated age of 13,397–13,085 calBP, and two assays on twigs from the intestinal contents returned calibrated ages of 13,441–13,141 calBP and 13,748–13,276 calBP (Fisher et al., 1994). Readers of this account will recognize that similarities between the Burning Tree and Heisler sites raise the possibility of comparable site formation processes, and yet differences between the sites challenge any simple equation of the two. The Burning Tree intestinal mass was narrower and longer than the ovoid mass at the Heisler site, more likely representing small intestine than large intestine. More importantly though, the Burning Tree mass had no dense clastic component, which seems to preclude the possibility that it functioned as any type of anchor. Did it represent simply a bit of intestine left attached incidentally to one of the articulated series of thoracic vertebrae? There was also nothing resembling a vertical marking post. Picking up other practical issues, would preservation of carcass parts in a peat-forming lacustrine setting parallel whatever might happen in a marl-bottomed pond? A substrate of plant remains maturing to become peat would probably be easier for humans to negotiate on foot than a marl substrate. For someone transporting a burden, a marl substrate with underlying clay could have posed significant risks. As noted above, many such questions cry out for experimental evaluation.

16.4 MICROBIOLOGICAL ANALYSES

A central component of interpretations forwarded here is that the ovoidal and cylindrical accumulations of plant material recovered at the Heisler and Burning Tree sites, respectively, represent intestinal contents of the mastodons found at each site. Although this idea is by no means implausible, it certainly qualifies as a "bold hypothesis", inviting a concerted effort at refutation, if not falsification (Popper, 1935). Indeed, it would have been easy enough for this hypothesis to have failed completely. Instead, it seems to have been corroborated (Lepper et al., 1991). The first step in this process was the threefold outcome of successfully culturing *Enterobacter cloacae* from the cylindrical mass at the Burning Tree site, failing to find this taxon in control samples from the surrounding peat, and recognizing in those control samples two bacterial taxa that are common in streams and freshwater environments. In contrast, *E. cloacae* is routinely encountered in the intestinal tracts of mammals.

As if this were not enough, we later undertook a more detailed analysis, with higher standards for species-level identification (Rhodes et al., 1998), for which the outcome was fundamentally similar. In this study, we identified a much greater diversity of organisms in Burning Tree intestinal samples. We used two sets of control samples: peat from the same stratigraphic setting as the intestinal sample but that was not located near it, and yet was found near bones; and peat from the same stratigraphic setting but not near either bones or the intestinal sample. In both cases, we found different organisms, indicative of different microenvironments. In this study, Burning Tree intestinal samples yielded a much stronger signal of mammalian enterics. This also helped to reduce the likelihood that the bacterial taxa we recovered were simply part of the normal microbiota of this type of environment that had somehow colonized Burning Tree samples long after the death, deposition, and decomposition of the mastodon.

Heisler intestinal and control samples examined by Rhodes et al. (1998) showed the same general patterns as had the Burning Tree samples. Intestinal samples again yielded bacterial taxa normally found in mammalian intestinal tracts, but the Heisler enteric assemblage was less diverse than that of the Burning Tree small intestine. This difference could be due to a variety of factors, but we suspect it mainly reflects the disturbance to the enteric environment caused by introducing sand and gravel to transform a piece of mastodon large intestine into a "clastic anchor." Control samples of Heisler marl were again different from intestinal samples, but because of the lower overall diversity, the distinction was less clear in quantitative terms.

16.5 EXPERIMENTS IN UNDERWATER STORAGE OF CARCASS PARTS

The first formal description of experiments on underwater storage of carcass parts was in a presentation at the 1989 Annual Meeting of the Geological Society of America (Fisher, 1989). The idea for such experiments had been gestating since early in our work at the Heisler site and had matured with exposure to many of the other mastodon sites I had come to know. This is not to say that every mastodon site fit the same pattern. Indeed, some clearly did not (an early example was the Johnson mastodon site, UM 57648, discussed in Fisher, 1984b). Nonetheless, the explanatory power of the idea of underwater meat caching was unlikely to be understood or acknowledged without a concerted effort to test its feasibility. Moreover, experimental approaches often bring to light unanticipated factors that complicate, threaten, or even synergistically support the ideas that originally motivated experiments. I could not travel back in time, but I should be able to find environmental settings that approximated those represented by the lithologies and stratigraphic sequences common at mastodon sites.

The University of Michigan's Department of Ecology and Evolutionary Biology, in which I have an appointment, manages a fenced experimental facility, the E. S. George Reserve, near the small town of Hell, Michigan. Tourists never tire of sending "Wish you were here!" postcards from Hell, Michigan, but just a few miles away, field ecologists are often quietly at work inside the locked gates of the George Reserve. After arranging permission, I explored two sites. The first was Crane Pond, a shallow pond similar in size to the former Heisler pond. Its water was the color of tea, with dissolved tannins that I expected might help with meat preservation. On its bottom, I found areas of both silt and marl deposition and an aquatic snail fauna that matched taxa common in the Heisler marl. The second site was Big Cassandra Bog, where a *Sphagnum* peat bog approximated the depositional environments of both the Pleasant Lake mastodon and the Burning Tree mastodon.

In addition to protected natural environments, the George Reserve has a "managed" population of white-tailed deer (*Odocoileus virginianus*), but no stable population of natural predators. Every two years, marksmen are hired to cull the population. Most of the meat is donated or sold locally, but heads that would otherwise be discarded can be obtained on request. Thus, in the fall of 1988, I obtained my first experimental subjects. Deer heads offered nothing like the quantities of meat I wanted to investigate, but their numbers made up for what they lacked in mass. I placed multiple heads in each of the two environments, to try out multiple "treatments" in each setting. I planned to check some heads at intervals of weeks to months, but to be sure this much activity did not itself complicate matters, I planned to leave other heads unchecked until the following spring, summer, or longer. I used artificial anchors to hold each experimental subject in place, realizing that even in George Reserve, small- to medium-sized scavengers (especially snapping turtles, *Chelydra serpentina*) might remove or consume specimens that I had intended to revisit. As further insurance, and to better discern what size of scavenger might be responsible for any damage I observed, replicate specimens in Crane Pond were placed within stainless steel cages. Finally, as a step in the direction of considering larger masses of meat, I purchased several legs of lamb—a "carcass part" that I could obtain commercially and that better represented a significant, even if still modest, mass of meat, fat, and bone.

Installation of meat caches in Crane Pond was easier for me than it would have been for humans at the Heisler site. I did not have a floatation bladder, but did have a kayak. I waited until October to install autumn meat caches, to be sure that snapping turtles had entered dormancy, allowing my experiment at least to start without their interference. In open-water seasons, I could paddle out to my stations, marked with a small buoy, and either install or check my caches, averaging visits every 2–4 weeks. When the pond first began to freeze, I could break through ice with my paddle and lurch forward like an ice-breaker, but the job actually became easier when the ice thickened. Trading my paddle for two rock hammers, I used them symmetrically to grab purchase on the ice surface, then pull myself forward in long, smooth slides. I had learned in the autumn that there were "warm" spots where spring-water bubbled up from below, making the ice thickness variable from one area to another. For convenience and safety when I was there alone, I routinely used the kayak for this work, but I have done enough winter swimming in cold regions to regard retrieval of stored meat possible even without a boat. In early April, I saw the season's first snapping turtles, and in short order, all my uncaged Crane Pond meat caches had vanished.

As anticipated, installation and checking of meat caches in Big Cassandra Bog was much easier. I could walk out on the bog surface, dig into it deeply enough to bury my subjects securely, and check them (once a month) to monitor their progress. I realized that installing or retrieving a large carcass part would be a wet job, but what important activities of subsistence and survival do not entail some challenge? I did not have what I considered an effective cage for meat caches in peat, but I buried caches under at least 30 cm of wet peat and never experienced losses to scavengers in Big Cassandra Bog. It seems likely that wet peat would act to inhibit diffusion and release of microbially produced odors (from the meat) that might attract scavengers, but prior to running the experiments, I did little to investigate this further. I knew that no fence would exclude avian scavengers, and recent inquiry (pers. comm., E. E. Werner July 2020) has clarified that exclusion of mammalian carnivores from the Reserve is far from complete, thanks to multiple places where they can wriggle under the fence. Red foxes (*Vulpes fulva*) and smaller carnivorans are seen frequently, and even coyotes (*Canis latrans*) appear occasionally. It thus seems likely that burial of meat in peat greatly reduces the odds of loss to scavengers.

Most monitoring of caches was decidedly "low tech." My field kit included a utility knife, a pair of dissecting scissors, a metric folding rule for depth measurements, a general-purpose lab thermometer precise to 0.5° C, several litmus paper dispensers (with precision of at least ±0.5 on the pH scale), miscellaneous sample containers, and a field notebook. Temperature readings were taken for air (in shade), the medium in which meat was stored (bottom water or peat), and the interior of a meat mass (by inserting the thermometer bulb into a slit cut with the knife). Measurements of pH were taken by applying pH paper to a freshly cut tissue surface (or into water). On two occasions, I borrowed a dissolved oxygen meter and found that water directly around my samples had low, but variable oxygen levels, whereas bottom water was effectively dysaerobic (0.1–1.0 ml dissolved oxygen per liter of water). Data reported here are gleaned from summary reports and notes; original data are in on-campus files to which I have no access during the COVID-19 pandemic lock-down. In retrospect, the greatest shortcoming of the experiments on meat storage described here is their almost exclusive focus on qualitative aspects of preservation that collectively address the issue of whether underwater storage "works" to preserve carcass parts over time intervals that are meaningful for human subsistence. Left mostly unaddressed are details of taxonomic composition of the microbial communities responsible for the transformation of tissue properties over the course of the first year or so of preservation. This partly reflects the preliminary nature of these experiments, but more fundamentally, my own lack of training in microbiology. It was not until I began to collaborate with J. M. Tiedje and colleagues at Michigan State University that I gained a greater appreciation for what might have been possible. A well-controlled, tissue-specific microbiological study of carcass preservation in natural environments would require replication of parts of this work, but discussions are currently underway that could lead in this direction.

As summarized in Fisher (1995), the condition of fresh meat changed very little from mid-autumn through mid-winter. I did not try eating the deer heads, since I had essentially no control over their earlier history, but based on my visual, tactile, and olfactory assessment, especially in light of later developments, I am confident that fresh deer handled in this fashion would have remained in edible condition. By mid-winter, where muscle tissue was exposed, a zone of incipient degradation had formed, marked by translucence and a flaccid texture dominated by connective tissue and extending inward about a centimeter. Meat just inside of this translucent zone was slightly softer (than it had been before), and its color had begun to fade. Inside of the translucent+faded zone, the meat looked as fresh as before, but had begun to smell slightly sour. Where fat was exposed, this surficial degradation was barely discernible. By mid-April, a trajectory of transformation had been established and only became more pronounced. Green and red filamentous algae were by then established on the outer surface (whether it was muscle or fat), and the outer transition (translucent+faded) zone (still mainly developed on muscle) remained, thickening moderately. The pink color of the interior remained, but the sour smell was stronger and was now joined by the smell of strong blue or Stilton cheese. By May, the strong cheese smell dominated. Brain tissue in the deer heads was only examined relatively late in their storage history (April–July). By this time, it had a tofu-like consistency and the same strong smell as muscle tissue. The legs of lamb experienced exactly the same transitions observed in deer muscle and fat. It was in fact easier with the lamb to observe the zonation and changes in texture, given the larger starting mass and simpler geometry (Fig. 16.5). Lamb samples included more conspicuous deposits of fat than were present on the deer heads, and this tended to retain its firm texture longer, whereas muscle became notably softer and easier to tear apart, or even, in advanced stages, to tear off the bone.

In April of 1992, several years into the project and already with strong suspicions as to what was going on, I submitted two samples of "cured" lamb to Analytic & Biological Laboratories, a commercial food testing firm in Farmington Hills, Michigan, along with a control sample cut from one of my legs of lamb and stored in my home freezer since the day it had been purchased. The only pathogens noted in the lab report were from the control sample, but they were present in such small concentrations that they were interpreted as the sort of minor contamination that affects much of our commercial food supply and is normally killed by proper cooking. By comparison, the pond-cured lamb showed only non-pathogenic organisms, such as lactobacilli. It seems probable that it was their growth in the meat mass that was responsible for its sour, cheesy smell. Although the testing was done on a leg of lamb from Crane Pond, both deer and lamb from Big Cassandra Bog behaved identically. Following these test results, and encouraged by the consistency of all experimental outcomes and reinforcing themes in the food science literature (e.g., Pierson et al., 1970), I started to consume small quantities of Crane-Pond-cured lamb and never had any adverse effect. The culmination of this work was a nine-month replication of a cured lamb experiment for which the underwater recovery, processing, and eating were filmed for a television documentary.

Figure 16.5: Kayak-assisted inspection of a cured leg of lamb in Crane Pond, April, 1992. Meat mass, attached weight, marker buoy, and sampling tools on the deck of the kayak.

The George Reserve experiments were helpful, but after several repetitions, my thinking began to focus more on the questions that remained. Even these experiments left me ignorant of what might happen in much larger carcass parts, and the significance of the column of intestinal contents at the Burning Tree site was still a mystery.

In late January, 1993, I was contacted by friends and colleagues, G. R. Smith and C. E. Badgley with news that one of their Belgian draft horses, a 28-year-old mare, had died (of natural, age-related causes). If I was interested, they were willing to allow me to make her the focus of meat storage experiments. With winter already in full force, we met the next morning. There was a small pond on their property, about a meter deep. We knew little about its biota or chemistry but it resembled many other small ponds on the landscape. We butchered the horse using a combination of knapped stone and modern tools. Confident that stone tools would have worked, I was actually more interested in replicating some of the disarticulation strategies for which I had seen indirect evidence at my sites. Paramount, however, was getting the carcass processed and installed in the pond that day. As the carcass was segmented, each part was weighed, yielding a total body weight for the horse: 680 kg. Carcass parts as large as 78 kg were installed in the pond by dropping them through holes in the ice, mimicking the Heisler site with several different clusters. The new element of these experiments was the size of meat masses. In the interest of completing the job in time, we did not attach anchors to any of the carcass parts but we did produce anchors for evaluation. Initial densities of all carcass segments were great enough that they settled immediately onto the pond bottom.

We first used horse intestines (Fig. 16.6) to replicate sand anchors like those at the Heisler site, making them with pieces of large and small intestine about a meter long. One end of one piece was tied off with nylon rope to be sure it would remain closed, but two other replicates were constructed using a single overhand knot to close the first end of one anchor and a strip of intestinal wall to close the first end of the second. Contents were then shaken out, but with no concerted effort to remove everything. We then added several kilograms of wet sand and tied off the second ends. To facilitate episodic checking, we added a float to each anchor, on a long lead (so that it would never raise the anchor off the bottom), but for ease of management, the anchors were left as solitary features. Replicating the cylinder of (mastodon) small intestine at the Burning Tree site brought up another issue—the horse small intestine was more slender than mastodon small intestine. To explore options, I performed this replication with horse small and large intestine. I decided also to vary their lengths, making one cylinder from small intestine about a meter long, and two others from large intestine, each about 2 m long. I did not remove intestinal contents from any of these, but simply tied off both ends and placed them in the pond (again, with floats on long leads).

Our first check on the stored meat was two

Figure 16.6: Removal of intestines from a 680-kg Belgian draft horse in preparation for production of clastic anchors similar to those at the Heisler mastodon site and intestinal cylinders like the one at the Burning Tree mastodon site. G. R. Smith holds the visceral cavity open by raising the right hind leg, while D. C. Fisher gently removes intestines.

weeks after installation (mid-February). This required reopening our holes in the ice, as they had re-frozen promptly. Muscle masses were not perceptibly different from their original conditions. To facilitate future checking, we added marker floats on long leads to a few carcass parts and stuffed the floats back under the ice. Given the good condition of the meat, we decided to feed several pieces to three wolf x German shepherd hybrids who at the time were members of the Smith-Badgley household. They ate it enthusiastically. Two weeks later (end of February), our canid participants ate more of the meat and showed no ill effects, so I chewed on a small piece and then spit it out. To a lover of yoghurt and sourdough bread, its hint of a sour taste was interesting, but on advice from my wife (a nurse), I agreed to be cautious. Two weeks later still (mid-March), the canids and I were all in good shape, so I decided it was time to consume some of the meat. Ice was still in place on the pond, despite some surface melting. Through a freshly chopped hole, I snagged the lead of a marker buoy and hauled out a 14-kg quadriceps mass (Fig. 16.7). Its surface now sported a thin crop of filamentous green algae on the grayish-white outer transition zone. Cutting into the meat, I was not surprised (it was déjà vu after the George Reserve experiments), but gratified, to find that the meat inside was still a rich red color and firm to the touch. Slicing off a thick steak and smelling it, the sour hints were now stronger and more complex, accompanied by the unmistakable smell of strong cheese, such as a Stilton. I had brought along some firewood, explicitly to have a fire on the ice, repeating a pattern I had inferred for the Heisler site. When the fire burned down, I laid my steak directly on glowing coals, cooking it quickly on each side. As long as the moisture content remained high (I recommend not going beyond "medium-rare"), heat was conducted quickly inward, with little or no surface burning. A final task for the day was to check the intestinal experiments in the pond. The clastic anchors remained intact and at original density (judged by weighing them while still underwater). The real surprise was the two longer pieces of unweighted intestine. Despite having been placed on the pond bottom, they were now standing "at attention"! Their contents—what the horse had eaten as one of her last meals—had evidently started to ferment, and gas had accumulated toward one end of the closed length of intestine, lifting that end toward the surface. In response, the remaining contents had slid down to the other end, still on the pond bottom. The inflated top end of each column must at first have been trapped under ice, but it later emerged (melted?) through the ice as a rugby-ball-shaped balloon. C. Badgley reported seeing footprints of a red fox in the snow around these openings in the ice. Evidently, the intestinal

Figure 16.7: Pond-cured meat of a Belgian draft horse. Quadriceps femoris muscle group, removed from the front of one thigh by chopping through the patellar tendon, a practice for which there was evidence at multiple mastodon sites. Condition in mid-March, 1993, after six weeks of pond storage.

balloon had been interesting enough to smell, but not interesting enough to bite into.

The next time I visited the pond was in early April, 1993. The ice was gone, and all marker buoys had become moot, because almost the entire experiment was floating at the surface of the pond! The meat was softer in texture than before, and "expanded", much like a sourdough starter culture, although nothing had been added to it. The surface temperature of meat masses was the same as that of the water (no surprise), but 10–15 cm inside the surface, meat was 1°C. warmer. When the meat had been fresh, its pH had been about 6.5, but by the time it was floating, it was 5.5 (identical to the pond water), and later in April it was down to 5.25 (pond water still at 5.5). Gas was accumulating interstitially within meat masses, much as it had built up inside the lumen of the intestinal cylinders, but with an important difference. The fermentation process inside intestinal segments no doubt involved partially digested vegetation, but no vegetation was associated with meat masses. Instead, the ever-stronger smell of strong cheese suggested involvement of lactobacilli, and the accumulating gas was probably carbon dioxide. The intestinal cylinders, for their part, were more inflated than before. When their inflated ends had first come to the surface (mid-March), the tissue exposed was light-colored, moist to the touch, and low in profile. Just two weeks later (Fig. 16.8; early April), the inflated ends protruded farther out of water, and their upper surfaces had become "sunburned" and tough, leaving only their water-lines white and moist where ripples lapped against them. My first response to all these changes was consternation. At George Reserve, my meat masses were not large enough to produce and retain this much gas, or if they had, I had not noticed it. Securely anchored as they were, none had floated. Now I was concerned that segments of horse carcass floating on the pond surface would degrade with exposure to the atmosphere. At first, I considered simply adding more weights, but if this were the answer, even more anchors would have been needed at the Heisler site. Neither Pleasant Lake nor Burning Tree presented a comparable problem, because floatation would not be an issue for carcass parts covered by peat. Pressing down on some of the floating carcass segments, I realized how heavy and complicated an anchoring system would have to be to return all carcass parts to the pond bottom. Early humans in this area must have discovered a better approach.

Figure 16.8: Area of "horse pond" where segments of the small and large intestine had been placed, as seen in early April, 1993, after most ice had melted. In middle foreground are two brown, bulbous profiles (#1, #2), white along their waterlines. These are upper ends of two 2-m-long segments of large intestine in which fermentation gases accumulated at one end, lifting it to the surface, while intestinal contents slid to the opposite end, filling the intestinal lumen.

Within the next weeks, we had several spring storms, one of which brought severe winds. After this, I learned from my friends that we had another problem. Wind had blown several floating, un-anchored carcass parts ashore, where their canid companions had found and devoured two units. Of course, there was still plenty of horse in the pond, but it was now clear how a food reserve could be lost—if it floats and blows ashore, scavengers may well steal it. How could we prevent that? Thinking of relatives on the East Coast, where many people keep boats moored in a harbor, winds come up all the time, but only the worst winds blow many boats ashore. Moreover, anchoring boats never involves forcing them to lie on the sea-bottom! The strategy of a boat anchor is to keep a small weight (relative to the boat's mass) at the end of a long lead, such that the traction force exerted by the wind acts along a vector that almost parallels the ocean bottom. A relatively small anchor can then resist displacement. All I needed was to think of anchors as tether-points and meat as boats. Floating meat masses would never present a large profile to wind blowing across a pond, so the traction force that would need to be resisted would not be large.

In early May, I installed several small anchors and light tethers connected to each floating meat mass. It was still not clear that this would solve the problem of hungry scavengers, but we would see. When the canids were next out in our presence, they came eagerly to see if their humans had left any more of the horse for them. Nothing was on the shore, but they could smell the meat, floating on the pond. Swimming out to it, they tried to take bites, but as anyone who has "bobbed for apples" knows, biting into an unrestrained, resistant, freely floating object is not easy. The canids tired, and the floating meat masses were now secure from scavenging.

Additional visits to the pond followed, but subsequent changes were all gradational (Fig. 16.9). Meat masses gained further buoyancy, raising the importance of confirming what gas was being produced. A large syringe and hypodermic needle was used to extract gas, which was then transferred to a vacutainer and analyzed by quadrupole mass spectrometer by W. Patterson (pers. comm., June 1993), who reported that the gas was mostly carbon dioxide, consistent with the idea that lactobacilli were responsible for most of the fermentation. Water and meat temperatures increased with the progression of the season, but the meat interior retained its lead of 1°C. Meat pH also declined until it reached an observed minimum of 4.5 (cf. pond water, 6.4) at the end of July. Having decided to keep the skull intact, we did not investigate the brain. We enjoyed a series of celebratory "tastings", extending the experience to other colleagues. I acknowledge that only a few genuinely enjoyed it, but most others considered it a taste that "might possibly be acquired" with sufficient hunger. I know of no one who suffered any gastric distress.

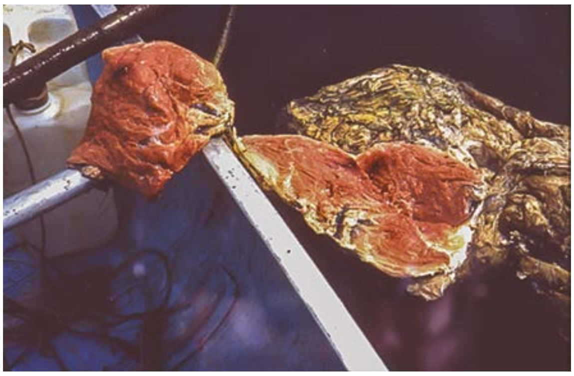

Figure 16.9: More pond-cured meat from the draft horse. Unidentified meat mass in late May, after almost four months of pond storage. Meat mass is floating, buoyed by accumulated carbon dioxide produced by lactobacilli and trapped within tissue. A piece of meat has been cut almost free and flipped onto the gunwale of an aluminum canoe used to monitor the experiment.

The ultimate resolution of the "problem of floating meat" is that it never became a problem. The micro-environment created by lactobacilli, through their lactic acid production and carbon dioxide generation, was maintained so securely that no pathogenic microbiota could gain a foothold. The meat remained distinctively tasty and nutritious, only becoming impractical to eat when it began to break down further in late July and August. And what did we learn from the intestinal cylinders? They were not anchors at all, but "marker-buoys" tethered to their own base!

Although I did not undertake detailed chemical or microbiological characterization of carcass parts undergoing fermentation in pond or bog settings, I did develop tentative hypotheses concerning processes that may be involved in this transformation. I suspect that key observations are the presence of lactobacilli (lactic-acid-producing bacteria) within muscle tissue, the low pH of the tissue mass (presumably due to the presence of lactic acid), and the sustained production of carbon dioxide (a normal product of fermentation by lactobacilli) that permeates and is initially retained within the tissue. Small amounts of carbonic acid derived from carbon dioxide may also be present. I also regard the strong, cheese-like smell as a telling indicator of the involvement of lactobacilli. The combination of low pH and anaerobic conditions (maintained by sustained production of carbon dioxide) appears to control the microenvironment of muscle tissue and adjacent fat, excluding bacterial taxa that might have taken over under more basic and/or aerobic conditions. Fat shows a more subtle change in texture than does muscle, becoming slightly "smoother", perhaps as connective tissue is "digested" by fermentation. Lipids themselves appear to remain stable at low pH, yielding a product reminiscent of the Russian delicacy "сало" [sa-la], which it closely resembles.

The development of algal cover on carcass parts is probably encouraged both by nutrients available within the tissue and by carbon dioxide production within the tissue mass. The "transition zone" at the surface of carcass parts probably develops due to the ease of diffusive loss of both lactic acid and carbon dioxide near the water/tissue interface, leading to more neutral (if not basic) and oxidizing conditions, promoting tissue degradation. The final breakdown of tissues probably coincides with loss of integrity of connective tissue, permitting more thorough dilution of lactic acid and loss of carbon dioxide, after which the microbial community responsible for fermentation may no longer be able to maintain its microenvironment. Muscle tissue appears to be lost first, but fats are eventually saponified (suggesting basic conditions) resulting in their transformation to adipocere. These interpretations are consistent with my limited reading of literature in the field of food technology (e.g., Pierson et al., 1970; Gill, 1983), but work dealing directly with circumstances relevant to my experiments has not been easy to find.

Another episode worthy of mention in this account of experiments in meat preservation was an "accidental experiment." In 1997, I was asked to recover the remains of a captive elephant that had died 17 years earlier and been buried in a substrate of lacustrine clay. The body had remained deeply buried since death, and even I assumed that all soft tissues would have decomposed over the intervening years. Imagine our surprise when our shovels exposed moist hide, inside of which was muscle, fat, and an essentially intact carcass. The odor was even stronger than anything the horse had generated, but its chemical affinity with the cheesy smell I knew so well was unmistakable. Equally interesting, in the handful of days devoted to recovery, transport, and "processing" of this elephant, all my steel excavation tools rusted more deeply than has ever happened in decades of recovering mastodons and mammoths—an indelible trace of contact with acidic tissue. As for why the carcass remained as nearly intact as it did, for as long as it did, my best supposition is that its secure repose within impermeable clay allowed its acidic and anaerobic microenvirnoment to remain unchallenged. However, even after the carcass was disarticulated, and much of the tissue was removed and allowed to decompose in an aerobic (outdoor) environment, it still took several years to break down, possibly because of metabolites that remained, or acid fixation of proteins (Gersten et al., 1985).

Finally, I would be remiss not to mention in this context the "natural experiment" of Lyuba, a woolly mammoth (*Mammuthus primigenius*) calf from the Yamal Peninsula (Fisher et al., 2012), whose exceptional preservation owed much to postmortem colonization of her body by lactic-acid-producing bacteria. In her case, lactic-acid-driven denaturing of Type I collagen (Dung et al., 1994) resulted in loss of a major structural component of both periodontal ligament and the tendinous attachment of muscles to bone (Fisher et al., 2012), hinting that this could be part of how and why pond-cured meat softens and detaches more easily from bone.

16.6 ADDITIONAL PLEISTOCENE REPLICATES

I would now like to address several Pleistocene sites in the Great Lakes region where new examples of some of the themes introduced above have come to light. Even generous time and space allowances permit only token treatment, but this should give a sense of developments to be explored in more detail in the future.

Although I have already discussed muscle tissue and fat, I have not yet addressed marrow. The first site mentioned, the Pleasant Lake mastodon site, had an intriguing record of bone breakage, but this appeared to be mostly associated with use of cortical bone for making expedient bone tools (Fisher, 1984a, b). No clear evidence of marrow processing was found there, or at the Heisler or Burning Tree sites. Nonetheless, marrow processing may have varied in importance according to circumstances. The Riley mammoth, excavated in 2009–2010 in central, southern Michigan, presented a strikingly different picture. This mammoth was an adult male, about 45 years old at death, with an AMS date of 14,390–14,080 calBP (Fisher et al., 2017). Season of death was early summer, during a musth episode (analyzed in tusk dentin), so the cause of death appears to have been a musth battle. The depositional setting was within, but near the margin of, a shallow pond on the Late Pleistocene landscape, and the remains consist of some whole bones and one complete tusk, accompanied by thousands of fragments of the cranium and various limb bone diaphyses, among other parts of the skeleton. The broken cranium and extracted tusks are consistent with harvesting of the brain and nasal mucosa, as proposed in Fisher (2009), and also with use of tusk pulp tissue. However, when the cranium is so extensively damaged, it is hard to point to evidence of processing beyond the fresh condition of bone when broken. However, limb bone diaphyses are more tractable. Multiple long bones of the Riley mammoth were split longitudinally, after which the marrow-containing cancellous interior of diaphses was gouged out, leaving almost empty cortical-wall segments. One of these is illustrated in four views, each 90° apart, in Figure 16.10A. The interior of the cortical wall is best seen in the second image from the top, and a close-up of the point of impact and tell-tale "stacked" impact fractures are shown in Figure 16.10B. Perhaps the most interesting point is that marrow recovery from many similar fragments was not necessarily the last step in their utilization. All fragments stripped of marrow were piled close to one another in shallow water near the pond margin, apparently to preserve access to them, perhaps for use as fuel. This presumes that long bone epiphyses, along with the cancellous interior of diaphyses, had already been processed for lipid extraction. The impressive utility of the pond setting was that it facilitated extended access to raw materials suited for multiple successive episodes of use.

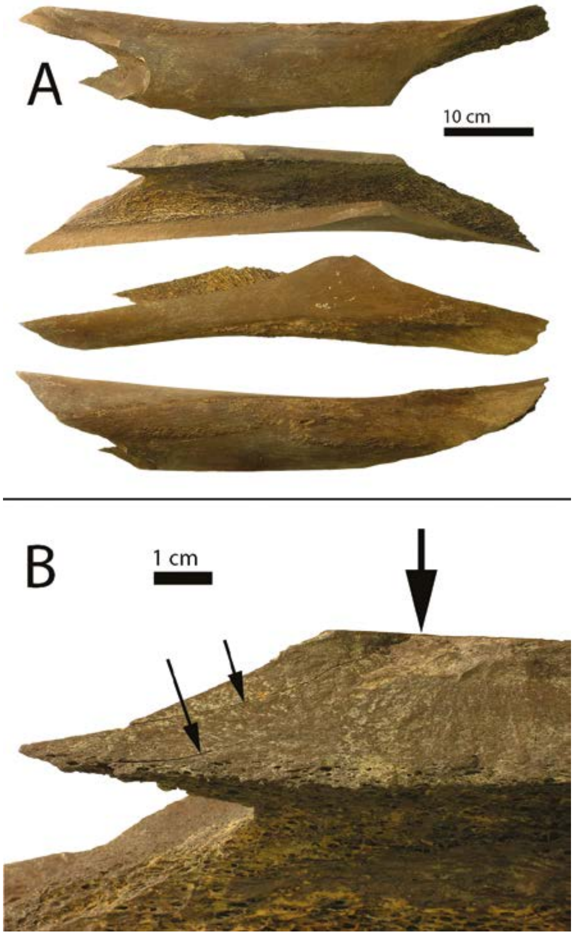

Figure 16.10: Green-bone-fractured segment of a femoral diaphysis of the Riley mammoth (UM 116967; Fisher et al., 2017). **A,** segment shown in four views, each rotated 90° relative to previous view. Marrow-containing cancellous bone has been removed from the interior of the cortical cylinder. All fractures were made on fresh, un-weathered bone. Upper-left corner of second image from top is enlarged in B. **B,** detail from A, showing point of impact (large arrow) and "stacked" conical fractures (small arrows) characteristic of impact fracturing by humans.

Another remarkable mammoth recovered recently is the Bristle mammoth (UM 117677), found on the Bristle farm, near Chelsea, Michigan, just west of Ann Arbor. A brief introduction can be

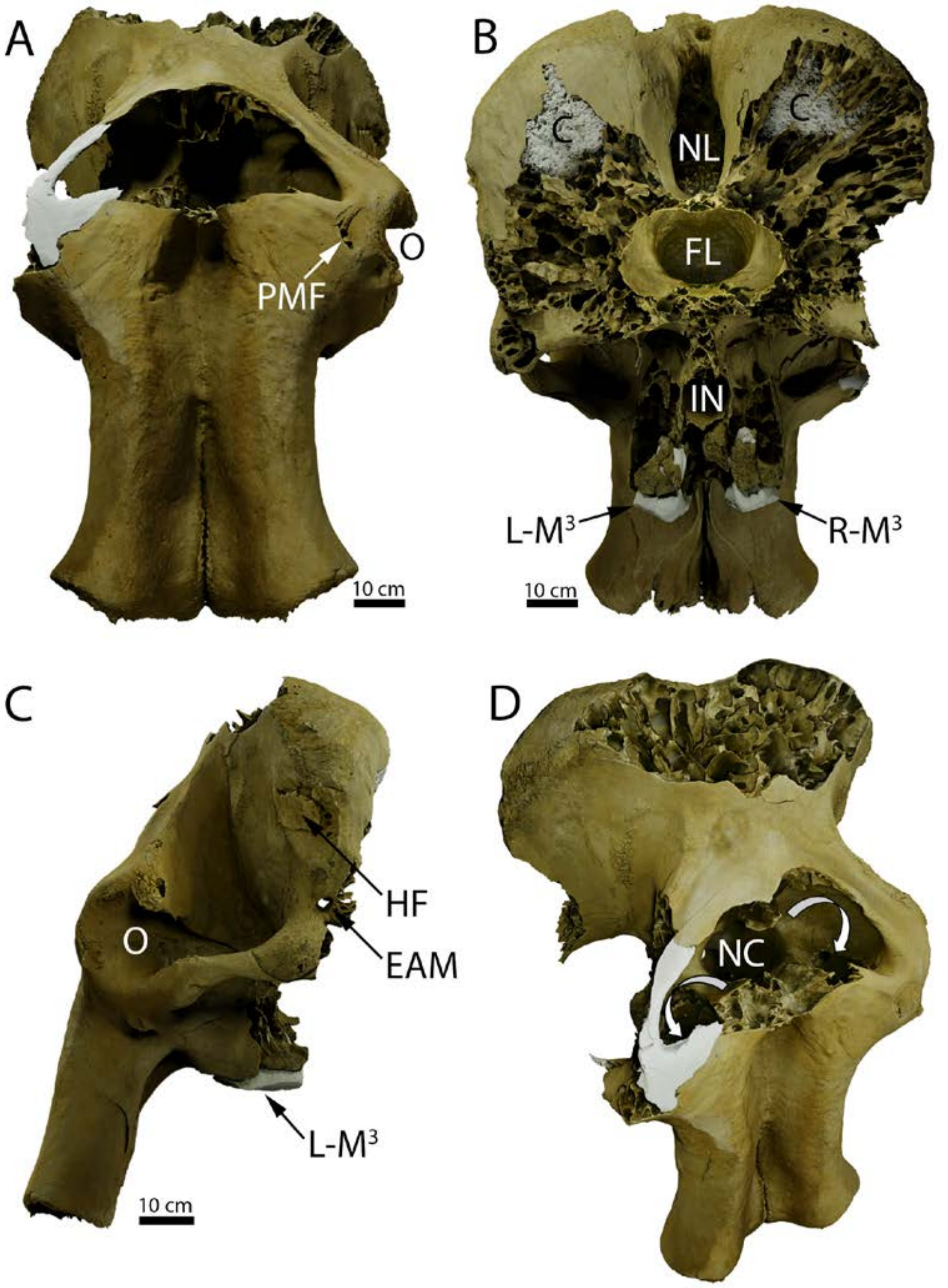

Figure 16.11: Multiple views of the Bristle mammoth (UM 117677) skull. **A,** anterior aspect, viewed along an anteroposterior axis parallel to the occlusal plane of upper molars L-M3 and R-M3 (white casts, visible in B and C). O: position of left eye (orbit) located at widest point on skull in this view. Perimortem damage over right orbit is repaired using 3D-printed replicas (white) of bone fragments. Opening on forehead just above level of orbit is the external narial recess, where the narial canals (within the trunk) descend toward the internal nares (IN) at the back of the oral cavity; PMF: perimortem fracture located just medial to left orbit. **B**, posterior aspect, viewed along same axis as A, but in opposite direction. C: light gray areas mark delicate regions, strengthened by consolidated beads of B-72 (acrylic polymer) used as supports for mounting; NL: nuchal ligament pit on posterior aspect of skull; FL: anterior portion of cranial vault occupied in life by frontal lobes of brain; IN: position of internal nares where narial canals open into the back of the oral-pharyngeal cavity. **C,** lateral view, with anteroposterior axis horizontal. O: location of left orbit; HF: healed fracture on lateral aspect of cranium, from an earlier musth battle; EAM: external auditory meatus (opening to inner ear). **D,** oblique anterodorsal view of skull, permitting a view into the passage for the narial canals (NC) connecting the external narial recess to the internal nares (IN). On both sides of the external narial recess (follow curved, white arrows) the boney ''floor'' separating the external narial recess from the interior of the tusk alveoli has been broken, permitting removal of pulp tissue from the base of each tusk without removal of tusks themselves.

viewed at the following internet address: <https://www.youtube.com/watch?v=XbekbGz1cEY>. The passing reference to a possible stone tool turned out to be mistaken, and we now know the mammoth was a Columbian x woolly hybrid, but other elements of this description held firm. Like the Riley mammoth, this male was a musth death. Most important is that the skull shows evidence of utilization by humans. Figure 16.11 offers a series of perspective views, rendered from a 12-million-face photogrammetric model of the specimen. White polyester resin casts of the upper molars were installed so that the real teeth could be kept separate for study. For the same reason, bone fragments from over the right orbit are replaced by 3D-printed replicas (white). The anterior view (Fig. 16.11A) shows one of several perimortem fractures (PMF) representing injuries sustained during the musth battle. The diametrically opposed posterior view (Fig. 16.11B) shows how the posteroventral portion of the cranium has been cleaved away (see also the lateral view in Fig. 16.11C) along a plane that extends from just below the nuchal ligament (NL, a massive elastic structure that runs posteriorly to the neural spines of anterior thoracic vertebrae), through the cranial vault, to exit the basicranium just behind the internal nares (IN) that mark the posterodorsal boundary of the oral-pharygeal cavity. This fracture plane lopped off the posterior two thirds of the cranial vault, leaving only the space for the frontal lobes (FL) of the brain in this portion of the skull, framed by the smooth, boney surface that conforms to the anterior aspect of the brain's temporal lobes. This fracture plane would have provided direct access to the entire cranial vault, allowing easy extraction of the brain. Finally, the oblique view of the skull (Fig. 16.11D) provides a "bird's-eye-view" from above, in front of, and slightly to the right of the skull. Looking downward toward the external narial recess in the forehead, the dark passage marked NC is the route by which the narial canals passed from the base of the trunk down to the internal nares (IN). Aside from this passage, there is normally no other exit from the external narial recess. However, in this specimen, the normally solid boney floor of the external narial recess has been breached on the left and right (follow both curved white arrows), providing access to the interior of each tusk alveolus (socket). Through these two passages, massive cones of pulp tissue could have been removed from the base of each tusk. All this could have been accomplished by breaking into the external narial recess through the broken area over the right orbit (white replica fragments). All of this breakage seems too precisely targeted to be explained as nothing more than incidental postmortem damage. For a better understanding of the structure of this specimen, I encourage readers to visit the University of Michigan Online Repository of Fossils (UMOR), where a version of this model can be explored: <https://umorf.ummp.lsa.umich.edu/wp/specimen-data/?Model_ID=1306>. Click on the static image to open the 3D viewer. After reading navigation instructions, close that panel and explore the model. Both tusks of this mammoth were found in their alveoli when the skull was discovered. We removed them for conservation following excavation, but all damage discussed above was present on the freshly exposed specimen. *In situ*, the anterior aspect of the skull faced downward on the soft marl bottom of the former pond. We therefore interpret the damage as targeted recovery of nutritionally valuable tissue by anatomically knowledgeable carcass processers. Our AMS age assay based on well-preserved collagen from dense cortical bone is 15,710–15,380 calBP (Beta-434390).

A final site is that of the Fowler Center mastodon (UM 118277), found near Mayville, Michigan. A photogrammetric 3D model made after some material had already been collected, may be viewed on UMORF at: <https://umorf.ummp.lsa.umich.edu/wp/specimen-data/?Model_ID=1298>. Although this model shows only about half of one cluster of material and none of a second, smaller cluster that together comprise the main portion of the site, it is still easy to recognize (note the ulna, nestled under the right innominate) that despite instances of residual articulation, multiple disjunct carcass segments are represented

Figure 16.12: Fowler Center mastodon site (UM 118277), revisited 18 March 2018. **A,** view toward previously excavated portion of site, marked by X, located about 40 meters south of current location. Just visible near the lower margin of image (indicated by white arrow) is a partially exposed rib from the posterior portion of a mastodon thorax, possibly representing a secondary locus of material from the same individual. **B,** closer view of rib, still *in situ* but further exposed (proximal end indicated by black arrow). Trowel points toward north. Excavation has almost reached stratigraphic level of rib.

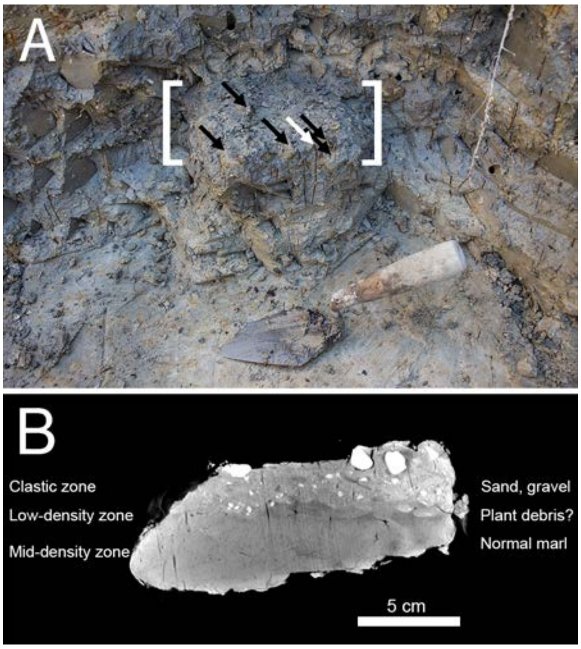

Figure 16.13: Terminus of apparent "clastic anchor" located near northern locus of material recovered from Fowler Center mastodon site, illustrated in Figure 16.12. **A,** trowel points toward north; view is toward ESE; rib is behind current camera position, at stratigraphic level indicated by white brackets, which embrace the constricted terminus of a concentration of gravel and sand that may represent the remains of a clastic anchor used to tether carcass parts to this location in the ancient pond. Black arrows indicate exposed gravel clasts. White arrow indicates one of several root traces that show that the gray marl exposed at this horizon has not been subjected to recent disturbance. Round holes about 1 cm in diameter (e.g., near top center of image) mark insertion points of stainless steel probe, testing for presence of gravel beyond the apparent terminus. **B,** one frame from a "slice-sequence" animation of the CT scan of the Fowler Center clastic anchor recovered from the site locus in Figure 16.12, where only a single rib remained.

here. This is again a male, older ontogenetically than the Heisler mastodon but younger than Burning Tree. He has a partly healed wound from a musth battle, but seems otherwise to have been in good condition. He is not yet dated, and we have not yet determined a season of death. Months after completing the excavation of this part of the site, I was contacted by S. Colling, who had helped with the excavation. He reported that at the same stratigraphic level as the original site, a single rib had begun to weather out of an exposure located about 40 m to the north of our earlier excavation (Fig. 16.12).

We met the next morning under freezing, late-winter conditions, to investigate this new locus. We decided to excavate from the frozen surface (Fig. 16.12A) all the way to the bone horizon, not wanting to miss anything with which the rib might be associated. The rib was in good condition, and not one of those already recovered for this animal (Fig. 16.12B), but no other bones seemed to be present. Troweling over a broader area to be sure there was nothing else, we encountered gravel less than a meter to the east of the rib. This gravel was not just a few clasts, but a deposit of some magnitude, covering roughly 1.5 m^2, with lateral limits tapering toward an abrupt termination in the southeast corner of our excavation (Fig. 16.13A).

This gravel was sedimentologically anomalous in the marl of this former pond. Most of the deposit was troweled into buckets, of which coarse clasts only comprise an estimated 16 kg out of a total mass of 36 kg of gravel and other sediment. After collecting all but the termination of this deposit, we troweled deeper to be sure nothing lay deeper in the sequence. We then used a stainless steel probe on the floor and side walls of the excavation to rule out the possibility that the gravel was part of some larger, more continuous deposit. No further gravel was encountered. Finally, the terminus itself was trimmed at its margins, undercut with a trowel, and transferred to a box for travel to the lab. Some of the gravel came loose during transit, but more (with its sandy matrix) was retained *in situ*, after which the remaining block was frozen. Later, we used polyurethane foam to encapsulate it, then dried and CT-scanned it. Figure 16.13B reveals, in stratigraphic order (from below, upward), a mid-density zone reflecting normal marl, a low-density zone (darker) that we suspect is plant debris, probably intestinal contents of the Fowler Center mastodon, followed by a clastic zone (bright white clasts) of sand and gravel. This is essentially a replication of the "lower hemisphere" of a Heisler-like clastic anchor, though larger and implemented in gravel. As such, it represents the most nearly intact clastic anchor to show up in 35 years.

16.7 DISCUSSION AND SUMMARY

Before considering what new insights the work discussed here may yield, I must acknowledge that most observations reported here are part of one "preliminary" study or another. Most of the sites need further documentation, and even the experiments could have been designed to provide a more complete record of events and interactions. That said, are there interpretations that used to be considered self-evident but that now seem less secure? My best answer to this question is the notion that Pleistocene proboscideans were miserably inept and prone to meet a soggy end, unable to extricate themselves from one of the wetland settings that were so common in their normal habitat. I cannot say this never happened, but I have yet to encounter a site that securely fits this description.

The flip-side of the existence question posed above is whether any question that used to defy resolution can now be answered more confidently? Here we need only look at one of the sites discussed above, such as Pleasant Lake, Heisler, or Burning Tree, and ask what site formation processes (if not pure ineptitude on the part of the proboscidean) could account for the overall site configuration? For this, I think we now at least have an interesting candidate involving underwater storage of carcass parts by Late Pleistocene humans. To be sure, this explanation depends on propositions that could never have been taken for granted initially, such as the feasibility of using underwater storage to significantly extend access to a resource composed of meat, fat, and "accessory" tissues. Nonetheless, this practice now seems grounded in dependable aspects of the natural history of microbial systems. Such evidence builds on ethnographic cases of underwater meat storage cited previously (Fisher, 1995), involving "Labrador Eskimos" visited by William Turner in 1780 (Taylor, 1969). Based on their location, these hunter-gatherers may have been earlier generations of the Innu discussed by Tanner (this volume).

Beyond delivering yes or no answers on singular propositions, discovering new aspects of human subsistence behavior has the potential to shed light on numerous facets of hunter-gatherer ecology. Reasons humans engage in one practice or another are usually much more complex than simply "Does the action achieve the intended goal?" Alternatively, it might be more useful to acknowledge that we usually need to manage a number of goals in parallel, each associated with different time scales of investment and return, and different risk/reward probability distributions. We want to "get the job done", but in a way that conserves time and energy, minimizes risk, and maximizes flexibility and multiplicity of downstream options. In that spirit, I have reflected on the value of underwater meat storage previously (e.g., Fisher, 1995). It requires minimal investment of time, once the resource has been procured. With helpers knowledgeable of the routine, even a large carcass might be dealt with in a day or two, requiring no further oversight, nor any risk incurred to protect the resource, until the occasion of first recovery. Any additional processing required can be done when the need becomes acute, and the rest remains secure—for a time. A stored resource may affect the calculus governing decisions about mobility, but it may also represent the difference between life and death in a time of stress. The useful life of the resource appears to extend at least until the end of the first summer following emplacement, but under colder Pleistocene conditions, it might have lasted longer. Almost inevitably, "shelf life" was sometimes exceeded, and when it was, the resource was abandoned. For Pleistocene humans, this was just part of the risk structure, and for us, this is how some of our record of such subsistence behavior develops. This is just one of many opportunities for reciprocal illumination, by which I mean that whenever we learn something about ancient human behavior, we also stand a chance for new insights into the nature of our historical record. If underwater storage of carcass parts was as common as I suspect it was, we probably have a much richer record of human interaction with megafauna (involving cases of both hunting and scavenging) than many archaeologists anticipate. Likewise, we may have a rationale for why recovery of lithic artifacts in association with stored carcass parts is not the norm, changing our understanding of the kinds of evidence that may be possible, vs. the kinds of evidence we choose to consider essential, for recognizing cases of human-megafaunal association. Pressing this issue, I argue above that human dexterity and ingenuity is implicated in the processing of the Bristle mammoth skull. I reported our AMS age estimate for this specimen without any fanfare, but some may consider this age "too early" for the North American Midcontinent. Further discussion is always warranted, but I encourage readers to ponder this conundrum. What data do you accept on their merits, and what do you accept only when other conditions are met? We are not necessarily mistaken to perceive a complex web of contingency among interrelated propositions, but we must be careful not to impose *a priori* limits on our reasoning to the extent that we are unable to recognize novelty when we stumble upon it.

One of the most interesting recent developments relevant to this work is John Speth's (2017) paper on what he refers to as "putrid meat." He and I have discussed such topics on multiple occasions, and we share a great deal of common ground. I completely agree with his emphasis that "just because meat is putrid does not mean it contains unsafe levels of pathogens" (Speth, 2017, p. 49), and he correctly recognizes this as a position supported by my "pond storage" experiments. At the same time, he refers frequently to "fermentation and putrefaction" (2017, p. 45) in a way that leaves me uncertain as to how he distinguishes these processes or if indeed he thinks of them as positions along a gradient. Both are said to induce breakdown of proteins and fats that is functionally similar to cooking, suggesting that this may afford an "energetic benefit" (2017, p. 48) to the consumer of such tissue. I am completely open to this suggestion, but I suspect we would all benefit from a more thorough treatment of the "systematics" of alteration paths to which fresh tissue is exposed, articulating what transformations normally occur, and what states do, and do not, usually convert to one another. My knowledge is probably fragmentary, but I tend to think of fermentation as an anaerobic process that when mediated by lactic-acid-producing bacteria, maintaining low pH, yields products for which examples are found throughout my catalog of experiments. On the other hand, typical "road-kill" occupying an aerobic environment and characterized by neutral to basic conditions, yields products with which I am indeed familiar (some of which I think of as "putrefied"), but are nothing like pond-cured meat or fat. In any event, Speth goes on to suggest that putrefaction, by which he here seems to refer to anaerobic, acidic, fermentation mediated by lactic-acid-bacteria (Speth, 2017, 2019a), tends to preserve concentrations of vitamin C that can be found in some, but not all, fresh tissues. This obviously would represent an important, unanticipated, contribution from eating fermented tissues. Speth was later obliged to respond (2019b) to criticism from Guil-Guerrero (2019), but made a solid case for his proposal. I would ordinarily not presume to step into such a discussion after the fact. However, by chance, at a time when I was too fully occupied to follow up, a colleague who knew of my meat storage experiments recounted an insight (pers. comm., D. M. Raup† November 2000) from his father, a botanist who had done extensive field work in the North American Arctic and had often worked with indigenous informants. His recommendation? "Vitamin C is a major factor!"

For one more suggestion on the possible significance of pond storage of carcass parts, proboscideans have a reputation for being "ecosystem engineers" (Fritz, 2017), but Late Pleistocene human hunters and foragers probably dabbled in this practice as well, taking steps to configure an environment that suited their needs. Al Holman, above all else, was a herpetologist, and as we began to work at the Heisler site, I remember him wondering aloud, why were there no Pleistocene specimens of snapping turtles in the Great Lakes region, despite every indication that the environment then would have suited them well. At the time, neither of us had an answer, but I wonder now whether early humans in this area, dependent on consumption of pond-cured resources, trained their children to collect the round white eggs of snapping turtles, praising the skill of those who succeeded and thus protected the family's access to critical carcass units.

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4 Ethnology – Human-elephant interactions in recent Africa

17. BAYAKA ELEPHANT HUNTING IN CONGO: THE IMPORTANCE OF RITUAL AND TECHNIQUE

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ABSTRACT

This chapter offers preliminary observations of Mbendjele BaYaka hunter-gatherer elephant hunting in the Republic of Congo. Elephant hunting has a long history in this region and the BaYaka tradition described here appears to be part of this. Elephants pose real danger to humans and killing one with a spear is daunting. Hunters take significant risks to approach and kill these huge animals, and this may partially account for the importance of rituals associated with elephant hunting. The success of elephant hunting crucially depends on women's ritual work in catching the elephant first and pressurizing the men to go out for it. The women's rituals also remove the potential for status accumulation by elephant hunters by attributing their success to women. Traditional techniques for killing elephants and how they are learned through games and multimodal storytelling styles are described. The role of a ritual association for elephant hunters to learn to read elephant behavior and to share mystical and practical techniques for hunting elephants is presented. In the context of spearing elephants, daring to try may be as important as knowing how.

17.1 INTRODUCTION

> *"Lovango, useth to vent yearly a great abundance of Ivory; but every year the quantity decreases, because the Blacks fetch it so far out of the Countrey, and carry it upon their heads. The chiefest place where the Staple for this Commodity remains, is call'd Bakkamele, about three hundred miles up into the Countrey."*
> *(Ogilby, 1670: p. 502).*

The Portuguese developed the early Atlantic trade with Central Africa from the 15th century to obtain ivory and copper. The coastal Central African Kingdoms of Loango and Vili (Luanda) with whom they traded had links up river to the kingdoms of the Teke from where they obtained ivory (Atmore and Oliver, 2001: p. 165). Before the King's Cloth sit some Dwarfs, with their backs towards him: Pigmies indeed in Stature …they wear the skin of some beast tied around them. The *Blacks* say there is a Wilderness, where reside none but men of such Stature, who shoot those Gigantick Creatures the Elephants". The common name of these dwarves is *Bakke Bakke*' (Ogilby, 1670: p. 508). Bahuchet adds that these dwarves knew how to become invisible when hunting elephant. They ate the flesh and traded the ivory with the "Jagos", clients of the Loango kings. The Jagos called these small men the "Mimos and Bakke-Bakke" (Dapper, 1686: p. 358, quoted in Bahuchet, 1993: p. 162).

By the 19th century the coastal kingdoms had developed trading relations with the Bobangi "people of the River", who became the key suppliers of ivory and other forest produce coming from the interior basin of the River Congo and its Ubangi tributary —the BaYaka[1] region today. The Bobangui language became the trade language of the basin, now known as Lingala and remains the lingua franca. The shared words for many forest animals between BaYaka and Lingala suggest that Lingala emerged from Bobangi traders' need to obtain goods from BaYaka.

Ivory carvers across the ages value African forest elephant tusks for the fine crosshatched microstructure of its grain. Forest ivory can be chiseled from almost any angle with comparatively little weakening or splintering allowing the finest detailing. The gel emitted from its pores eases cutting and produces a characteristic mellow sheen once polished. Such qualities make forest ivory the most sought after ivory.

The BaYaka value elephants (the African forest elephant *Loxodonta cyclotis*) for the fat and meat they provide, rather than the ivory. The BaYaka with whom I stayed have over 20 names for different types of elephants. These include *njoku* - elephant; *aŋgo* - unidentified large adult; *kamba* - dominant male; *dilomi* - second male; *epombi* - rogue/lone male; *ɛtina* - adult female; *mbutu* - elephant without tusks, and others that refer to different juvenile states, whether a cow is gestating or nursing, and names for different family group configurations, and even a mystical elephant with six tusks called *ɛyiti naba njoku*. This developed vocabulary for elephants reflects the importance they play in BaYaka life. Though meat and fat are what matters most, ivory gave BaYaka access to goods from outside the forest through the Atlantic Trade, which they have probably been supplying ivory to for around 500 years.

In recent decades, numerous professional non-BaYaka teams working with high-powered rifles have contributed to supply a renewed demand for ivory from Asia. From the Millennium to 2013, Congo Basin elephant populations declined by two thirds (Maisels et al., 2013) as expanding road networks into remote forest areas facilitated such teams access to remote populations (Lewis, 2020). These commercial forces and the militaristic response from conservation organizations have created the conditions for BaYaka elephant hunting to be almost non-existent today.

17.2 ELEPHANTS ARE SCARY

Although I have never witnessed an elephant being killed, while we were in the forest three elephants were killed and we joined the feasting. I once participated in an unsuccessful elephant hunt when we moved camp in deep forest and encountered a large male by chance. I was walking with Phata, an elderly *tuma* (elephant hunter), and he took up the chase and I followed. Phata was one of the most accomplished *tuma* in my research area and my key informant on elephant hunting techniques. He had killed seven with a spear, and many more with rifles and shotguns. His father Mosanya was said to be able to tickle elephants, once famously returning with an elephant's tail hairs to show the other men that the elephant was too small.

The Congo Basin's forest is particularly dense

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[1] BaYaka refers to Pygmy groups in the Western Congo Basin; other names such as Mbendjele, Mikaya, Luma, Ngombe, Baka, etc. are self-ascribed ethnonyms used to distinguish between Pygmy groups who each occupy different territories.

with undergrowth making it hard to see much around you, so hearing is central to informing you of what is nearby. As I chased Phata through the dense undergrowth the noise I made brushing past the leaves was so loud I could no longer follow the sounds of the elephant. I stopped the chase, Phata continued. One tactic elephants have for defending themselves is to flee, but then stop suddenly, hiding themselves so that they can attack who ever (leopard or person) is chasing them. If caught, the attacker is picked up by the trunk and violently shaken from side to side to break their spine. The attacker-now-victim is then thrown to the ground, trampled and tusked before being left for dead. I have witnessed the aftermath of several elephant attacks on people, in the three cases where I could interview witnesses and victims the injuries sustained where life changing, and in one case deadly. I provide brief details of these attacks as they provide context for my overall argument concerning the importance of cultural institutions and women's strategies to pressure men to take the huge risk of hunting elephants despite not accruing special status or wealth as a result of so doing.

In two attacks the elephants were young males, and in the third a mother attacked a boy who inadvertently walked between her and her calf. Both young males attacked conservationists studying them. In the first case, the conservationist returned from vacation in US to notice that a young male had joined the group he was studying. Unbeknownst to him, the young male stalked up behind him, grabbed him around the waist with his trunk, and shook him violently before hurling him to the ground and piercing his chest and thigh each with a tusk. The elephant returned to the herd leaving him for dead. Had he not been an American with full health insurance he surely would have died. However, he was helicoptered out and spent the best part of a year in hospital having his bones and chest put back together. He returned to his conservation work as soon as he was well. Three years later, the hole in his thigh was still big enough for me to place a clenched fist in the aperture.

The second conservationist did not survive. Walking back from her observation post along a wooden raised pathway to cross a marsh she suddenly found herself being chased by a young male known to be unpredictable. Rather than doing what BaYaka recommend —to use rapid just-in-time direction changes to exploit human turning speed against the elephant's weighty momentum— she ran in a straight line along the raised pathway. The doctor who did the autopsy explained to me that the elephant had borne down on her and hooked her with his tusk. The tusk entered her anus and lacerated her internal organs including her heart and lungs, quickly killing her. The doctor had never witnessed such severe internal damage.

In the third case, a group of BaYaka left our camp on a mixed gathering trip. A boy walking in dense forest accidently found himself between a resting mother and her calf. Before he knew what was happening, the mother had charged, knocking him over and began trampling him on the ground. A quick thinking *tuma* called Suke ran between the forelegs of the mother as she tried to tusk the boy, tossed the boy over his shoulder and fled the scene. Suke received a fierce tusk blow to the top of his head, lifting a significant piece of bone from his skull. Although the boy was saved, his legs were so badly broken in multiple places that he never walked again.

BaYaka are acutely aware of the great risk men take when hunting elephants and readily admit that although all men hunt other game, not everyone has what it takes to be a *tuma*. When I asked a close friend if he was a *tuma* he replied that he did not have enough courage (*nguli*). BaYaka men admit that hunting can be very scary. They sing a song when faced with a daunting opponent in the forest: *longokodi kaba me nguli* (chameleon give me courage). The fearful hunter chants this refrain while raising his chest and arms rhythmically until he feels he is ready to strike with the precision and force of the chameleon's tongue. Large game are dangerous opponents and hunting them is indeed a deadly combat. Hewlett et al. (1986: p. 60) stated that of the 11 individuals reported to have died in hunting and gathering accidents among Aka

(BaYaka) in Central African Republic, elephants killed three men in separate incidents. It is easy for those who have not witnessed such events to forget just how challenging hunting can be.

Despite these risks, a significant number of men in communities living in areas with substantial elephant populations are *tuma*. In one Mbendjele BaYaka community I know well almost half of all households had at least one *tuma*. When I surveyed their permanent campsite on the Sangha River in 1996, of 181 Mbendjele living in 46 individual huts, 20 huts were occupied by one or more *tuma* (Lewis, 1997: maps 99.1-4). Those households with more than one *tuma* were composed of father and grown son or sons living together.

17.3 THE IMPORTANCE OF SHARING

During the 1990s we made journeys of many months (*molongo*) moving through the forest with our BaYaka hosts. When moving camp, some hunters always leave well ahead of the noisy women, children and others to scout the area we are entering, and hopefully surprise some animals along the way. After a few hours walking, we would set up camp to spend some days or weeks exploring that area of forest. Leaf and liana igloo shaped huts are arranged in a circle in a cleared space around a central men's seating area called the *mbandjo*. Typically, when in camp women sit in front of their huts, or that of a friend, chatting in a distinctive melodic style while preparing or cooking food, doing craftwork or just passing time. Following the BaYaka's egalitarian principles, all produce taken from the forest in sufficient quantity is shared equally among all present. When much meat is killed, after sharing each hut erects a smoking table (*mutulaka*) to dry the meat to prevent it rotting before it can be eaten.

Sharing meat is crucial to a hunter's future success and is governed by a range of rules called *ekila* (Lewis, 2008). These rules concern many related aspects —such as not laughing at a carcass, or not boasting about hunting success, or not sleeping around. Among BaYaka, contrary to costly signaling models of hunting success, a good hunter must not sleep with women other than his wife. *Ekila* rules oblige the hunter to bring meat back to camp so that the men can eat the men's meat (*piko*) and so maintain the hunter's luck. Here, the hunter will receive a share of the meat as will anyone else, in contrast to the own-kill taboos among the Baka (Yasuoka, this volume). These rules are crucial for ensuring that hunters inform the camp of the kill – otherwise they might be tempted to simply eat their fill and abandon the corpse in the forest. If an elephant's *piko* meat is not shared with all men present, it will ruin the hunter's luck (his *ekila*) in future so that he will not meet game, will miss, or may be attacked by dangerous animals when next out hunting.

Benasongo was the most famous elephant hunter in the region I know well. In the 1980s he killed an elephant that had the biggest tusks seen in living memory. The villager whose gun and bullets he used took him to Brazzaville to parade along with the enormous tusks. This experience affected Benasongo profoundly and led to him being the only Mbendjele hunter I know that openly boasted about his hunting prowess "Now killing elephants, that I know well … I am very good at hunting animals. So good that my friends are angry with me" he told me in an interview in 1997[2]. Benasongo hunted so much that he would end up with piles of meat on his smoking table. When people saw this, they were appalled. "Pygmies don't hunt like that!" they would comment, implying that his *ekila* must be ruined from not sharing. But Benasongo so enjoyed hunting that he would continue regardless. He suspected that other men became so jealous and resentful of his success that they cursed him to meet gorillas when out hunting, or as Benasongo put it "I don't know what to think anymore, my life has been tied up by gorilla after gorilla!" I never met anyone who was so often charged by silverbacks.

Under pressure from his wife's father, Benaso-

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[2] The full interview can be watched at https://elearning.lse.ac.uk/dart/wgo/wgoLevel3.html

ngo opportunistically shot an elephant in a forest clearing in the early 1990s. While he butchered, others went to fetch the camp to come for the meat. They never returned: "Anger had entered the women" he told me. They had refused his meat. In addition to hunting too much and not sharing properly, he had not followed the protocol that requires women to sing *Yele* to first "catch" the elephant that a *tuma* shoots. If he was not reliant on their mystical prowess, he must be employing his own. This makes the meat he has killed tainted by illegitimate mystical forces and dangerous, so the women refused it. There was a huge row when he returned to camp having abandoned the meat where it was. Enraged, Benasongo left the area, effectively exiled by the women's collective refusal to cook his meat. He moved to live amongst a neighboring group of BaYaka Pygmies called the Baluma. In 2012, I met him again in a Mikaya Pygmy community. He may have been exiled again. Benasongo's boasting and over enthusiasm in using his exceptional skill as a hunter has been his nemesis, contrary to the assumptions of those evolutionary anthropologists projecting male costly signaling theories onto hunting success.

17.4 A WOMAN'S HUNT

Fat and meat for feasting is the principle objective of elephant hunting. Ivory is a bonus. Fatty meat is the most sought after meat by BaYaka —the arrival of a fat animal into camp provokes celebratory calls and hoots by children and adults alike. Of all game animals, elephants provide the greatest amounts of fat. This makes them extremely desirable. Given the risks associated with elephant hunting but its production of a huge amount of desirable fatty meat from the efforts of just a few men a complex of ritual practices surround the hunt that serve to incite men to go hunting, ensure that they share their production and prevent them from claiming special status. Ritual precedes the hunt, continues during it and erupts into boisterous feasting and raucous singing and dancing called "spirit play" (*mokondi massana*) that continue until the elephant is largely consumed. Feasting on an elephant can fuel weeks of music-making and dancing with forest spirits. It provides food to support some of the most important ritual events of the BaYaka. Given this, it is counter-intuitive to many non-BaYaka that a man, such as Benasongo, who excels at making this possible should be exiled and his meat rejected, rather than being celebrated and sought-after. To understand why, I shall outline the principle ways that elephants are hunted.

An elephant hunt is called "*mwaka ya baito*" (a women's hunt), even though no women accompany the hunters. Elephants may be encountered accidentally, and opportunistically hunted if a *tuma* is present, as Benasongo and Phata did above. But, upon entering an area of forest popular with elephants, or when commissioned by a villager supplying weapons and other goods, elephant hunting may be planned. In such cases, it is embedded in a ritual process that attributes responsibility for the success of the hunt to women's ritual work, and the couple's proper sharing of their respective production (Lewis, 2008).

This understanding of hunting success as based on the sharing relations and ritual activities of the hunter's spouse structurally resembles Bodenhorn's (1990) observations of Inupiaq whale hunting. Here it is a wife's ritual and moral behaviour that attracts whales to her husband to be killed: "I'm not the great hunter; my wife is" men explained to Bodenhorn. For Inupiaq, hunting is not understood as simply men seeking and killing animals, but rather as a conjugal activity emphasizing the co-dependence between men and women in producing the right ritual, moral and economic conditions for big game hunting to be a success. This is also the case in Congo; women's ritual activities around hunting and overseeing proper sharing are what ensure hunting success, and are intensified around elephants to prevent elephant hunters from claiming status or prestige because their success is attributed to the activities of their wives.

Figure 17.1: Elephant hunting spears (*ngongo*) from the southern BaYaka region. Note that as they are used they diminish from sharpening until they become spears for smaller game, such as pigs and antelopes (top right). Photo by Jerome Lewis

Once established in a propitious place, the camp prepares for an elephant hunt. Men prepare their spears (*ngongo*) by meticulously sharpening them until they have a razor edge, and cutting fresh shafts where needed. A long iron blade reinforced by a thick central spine to provide extra strength distinguishes elephant spears (see Fig. 17.1 and Bahuchet, 1985: p. 240 for examples from the northern BaYaka area). Before men embark on the hunt women first ritually "spear" the elephant by singing *Yele* long into the night. Drinking a special herbal potion women sing together to support some of them to enter trance. These women say that they fly over the forest seeking to locate and "tie up" an elephant with their mystical power (*gundu*).

When women "tie up" an elephant in this way they are said to *mo.kobie* the elephant. When spear hunting game, the hunter that first strikes the animal (*a mu kobia niama*) is considered the "hunter" of the animal. Others who strike afterwards to make the kill are said to *mo.koba*. When women drink their potion and sing *Yele* they are thrusting in the first spear. So when *tuma* leave to hunt they are going on a "women's hunt" (*mwaka ya baito*) to *mo.koba* the elephant. In general, the "hunter" is only named so as to ensure that he eats the hunter's *ekila* meat (often including the heart but varies with species and hunting method), which guarantees his future success. Those who *koba* another's animal also get specific cuts of meat: for an elephant the *koba* gets a forearm, with pigs the *koba* get the sternum and ribs, and so on. However, in the case of women they do not get the hunter's *ekila* meat. At this level the women's role is implicitly seen as symbolic.

To begin *Yele*, women decorate themselves with flowers and sit closely together to establish a strong singing group in camp. From time to time they stand up to dance up and down the central space. At certain points, elder women will cleanse bad luck from the camp, the hunters and their weapons by whipping them with leafy branches. The collective women do it to themselves too as they dance up and down. Women whose mother's have died whip both legs others whip one leg. Singing will go on for many hours. As women enter trance they adopt a characteristic pose with one arm raised above the head, forearm folded to rest across their foreheads as they rock back and forth while singing. Once the whole camp has been cleansed and one of the women says she has found an elephant they mark the success of the ritual by collecting together all the leafy branches used and collectively place them above the doorway of the *tuma*'s hut that they say will make the kill. The *tuma* is now under clear orders to leave in the direction they indicate to *mo.koba* the elephant that they have already caught.

Yele enables women to exert huge social pressure on men to go elephant hunting. Given the risks involved, it may be important to have such social mechanisms to prompt otherwise possibly reluctant men to go. Women continue singing *Yele* once the men have left. As many hours may pass, they stop and start, attending to domestic needs as required, but a core of women maintain the song throughout as they wait for the forest spirit *Moshunde* to arrive in camp to tell them that elephant is dead. With the arrival of *Moshunde* all present leave to the site of the kill to collect the meat. This is a moment of great joy and women and children sing loudly as they walk to the kill site.

On arrival, the men have normally made good progress in butchering the huge carcass and there are piles of meat waiting to be transported away. The most appreciated portions are those with the most fat, and those arriving first will take these. Most cherished are the fatty belly and chest meat, the fat around internal organs and the dense fatty pads in the elephant's feet that cushion its step. Large slabs have a head-hole sliced in the middle of them and are hung over small children's heads to wear as bloody tunics to carry back to camp. Women pack other cuts, especially the fatty ones, into their baskets, or bundle them together in leaf parcels to hang on their foreheads. If camp is too far away a new camp is built nearer to the kill site. It is important to make this some distance away —generally a kilometer or so, because the carcass may attract leopards during the night, and to avoid the inevitable stink that develops as the days pass.

Once meat is in the camp, while erecting huts and smoking tables, the children's forest spirit *Malimbe* journeys from hut to hut demanding the fattest cuts of meat, especially from the *tuma*'s wife. This musical and often comical animation is punctuated by meat sharing as more and more returns to camp and individuals send children with parcels of meat to other households. Fires everywhere are roasting select pieces, pots are beginning to stew, and conversations are lively. When all the men eventually return to camp with the last of the meat, adult spirit play begins. Often this begins with mischievous *Eya* forest spirits calling out raunchy, sexually provocative comments aimed at the women. Women respond back with humor, teasing and rebuttal. As food begins to appear, men sit in the central *mbandjo* area sharing dishes sent by the women, and women and children sit in front of their huts passing leaf plates to each other to share the different dishes. The elephant's feet are placed in the fire's embers to roast for many hours until the fat pads are liquefied and enthusiastically drunk direct from the huge foot. During feasting the melodious *Yolo* forest spirit is sung to celebrate the abundance of meat. A range of spirit plays, especially *Niabula* or *Bula*, may be performed late into the night.

In addition to whatever drum-like items can be found, from time-to-time men will beat the buttress roots of large trees to provide the percussive rhythm for the spirit play. This drumming carries far at night, alerting nearby camps that an elephant has been killed and that they are welcome. During daytime, signs made of a hooped liana the size of an elephant's footprint are left at key junctions on forest paths to tell others where to go. People often come from other camps to join the feasting. If enough people are present *Ejɛngi* is the spirit play of choice. As the forest spirit given by the women to the men to found BaYaka society in mythical times dancing *Ejɛngi* today is explicitly a celebration of abundance. Feasting, play with forest spirits, storytelling and romance continues until the elephant meat is consumed. We once spent two weeks doing so. How long depends on the size of the camp. Feasting on an elephant is one of the most cherished cultural events of the year and each feast is remembered so well that they become markers for how people discuss the past.

Figure 17.2: Charms and medicines key to elephant hunting success. Photo by Jerome Lewis

17.5 BULA

Of particular importance in this context is the forest spirit association called *Bula*, or *Niabula*; the elephant hunters' forest spirit. Often taken up by the initiated men once other spirit plays are over, they retire to their sacred path (*njanga*) some distance from camp to call *Bula* into their midst to dance. *Bula* is said to resemble an elephant, and in communing with it on the sacred path, men learn about the characteristics of elephant minds. *Bula* is one of the most secret of the men's forest spirits. It never dances in public, though its songs may occasionally be heard. Becoming an initiate and dancing with *Bula* gives men special powers and knowledge crucial for successful elephant hunting. Women must remain ignorant of men's tricks and techniques for catching wild animals and finding honey so that they depend on men for access to these valued items.

On *Bula*'s sacred path, in addition to dancing with *Bula*, men share specific hunting medicines and techniques for killing elephants. Practical lessons are provided by *tuma* theatrically re-enacting previous hunts with careful attention to the exact mimicry of the acoustics of the encounters, of characteristic postures, behaviors, actions and intentions of the hunter and the prey. These pantomime story-telling styles called *moadjo* (pantomime) used during *besimɛ* (recounting lived experience) are typical of hunting stories, priming watchers with knowledge of key sounds to listen for, and postures or behavior patterns to look out for in their future encounters with prey, and their options for responding. It is an education of attention without the danger of being in the presence of dangerous game such as elephants. *Moadjo* is the expected story-telling style when recounting witnessed events. Men's *besimɛ* tends to specialize on human-animal relations, women's *besimɛ* on human behavior (Lewis, 2014: p. 230).

In addition to this practical knowledge, men place great emphasis on the mystical knowledge that is required to safely kill elephants. While there are a great number of leaves, lianas and barks that provide important medicine to help hunters —by helping them see tracks, run fast, aim right, etc.— this knowledge is held by individuals and given on an individual basis, often when out hunting. Elements of this lore specifically for elephant hunting are secret knowledge. However, there are certain core charms and medicines whose existence is widely known, though their ingredients and fabrication procedures are not. I can share something about these items, illustrated in Figure 17.2.

A certain fibre string (*mokodi*) is tied around the forehead of the *tuma* to guide his senses and improve his awareness. *Moombi* paste, kept inside a horn, is smeared on the crown, forehead, chest and calves to make the *tuma* invisible to the elephant, keep him safe and on full power. The black rope called *ekooŋga* is worn around the waist or over head and shoulder and is said to be a medicine from the creator *Komba* that gives *tuma* the ability to kill elephants and protection when doing so, especially if forced to flee an angry elephant. The *esoŋgo* necklace keeps the wearer safe by providing foresight to anticipate accurately what will next happen. The *mondaaŋga* braclet is worn on the wrist. According to Phata, it is like a remote control that allows the *tuma* to adjust the position of the elephant, turning its body as the *tuma* turns the bracelet on his wrist, to get it to stand in the safest position for the *tuma* to approach. It is this combination of practical skills, advanced knowledge of elephant behavior, and the personal support of special charms and medicines that ensure elephant hunters have the practical knowledge and confidence to approach such intimidating prey.

17.6 LEARNING HOW TO KILL ELEPHANTS

I now turn to the more obviously practical skills needed by *tuma*. In contrast to many American hunters (see for example Tanner, this volume), BaYaka do not perceive of prey animals as giving themselves up. To the contrary, they emphasize that prey must be tricked and deceived, that hunters must use stealth and knowledge of the prey's habits and intelligence to succeed. For instance, when starting out to find an elephant men take off their clothes and their shoes. While it is the scent of fire smoke or soap on their clothes may alert the animal to the hunters' presence, they take off their shoes to be able to "hear" the elephants. Elephants communicate with low frequency rumblings that are difficult to hear, but can be felt as they vibrate through the ground alerting the hunters to their presence nearby. If fresh tracks of an elephant are spotted and a pursuit begins, as soon as the hunters come across the fresh excrement of the elephant they rub it over their whole body so as to give them the elephant's own smell. Men have developed disguised modes of communication for themselves, using bird whistles or sign language (see Fig. 15.3 for some examples) when near to prey to coordinate their actions without the prey realizing that they are there. But even with these precautions, *tuma* emphasize that it is vital to have the wind in your face and the sun behind you to approach close enough to spear.

My informants were skeptical that it was possible to kill an elephant safely by throwing spears at it. Such behavior would simply enrage the elephant and endanger the *tuma* and possibly others. Unlike throwing, their spearing technique uses the thrust of an outstretched right arm, with right hand grasping the back of the spear, while the left hand stretches forwards to guide the shaft to keep it on target. It resembles a guided thrust more than a throw. Accuracy and power are of the essence. Learning how to do this is an apprenticeship that begins in childhood.

Accuracy is honed through many hours of playing *ndaaŋga ya sooŋgo* as growing boys. In this game, the soft inner section of a plant, such as a banana tree, is turned into a rolling target thrown along the ground which boys spear using light, sharpened poles. Assisting in the butchery of elephants as adolescents is crucial for learning the intimate anatomical knowledge required to get a spear into an elephant's vital organs without getting blocked by its large bones. Once skill and accuracy in spearing large game such as wild boar or buffalo is achieved, and knowledge of where to strike an elephant has been learned a young man may, if he has the courage, be in a position to join a hunt.

When accompanying experienced *tuma*, such young men learn the art of tracking elephants by following the discussions of the *tuma*. They will not strike the animal, but will climb trees to watch in safety when the *tuma* prepares to strike. Occasionally when an elephant is found in a heavy downpour, a *tuma* may lead a small group of young men to the animal. When the rain is very heavy, elephants often seek shelter by poking their heads into dense undergrowth to keep the rain out of their eyes. According to my informants, the rain diminishes the acuity of their sense of smell and their hearing. This provides unique advantages that allow younger men, who are not yet *tuma*, to practice under the guidance of more experienced men. The more experienced men take up position near the elephant, often by climbing trees, from where they direct the youth who now try to put into practice their knowledge of approaching and spearing the elephant. Commentaries are offered to guide the youth. If a young man succeeds in

Embongo / Leopard

Njoku / Elephant

Mboko / Buffalo

Sumbu / Chimp

Ebobo / Gorilla

Ngwai / Pig

Moseme / Bay Diuker

Mbomu / Marsh Diuker

Bemba / Yellow-backed Diuker

Bongo / Bongo Antelope

Jongi / Aardvark

Mokwake / Crocodile

Kema / Monkey

Kalu / Colobus Monkey

Misime / Snake

Figure 17.3: Sandima demonstrates some of the sign language used by hunters when in the presence of prey. Photo by Nico Lewis.

killing an elephant, the kill is attributed to a *tuma*, only after several successes will a man be recognized publically as a *tuma*.

17.7 TO KILL WITH A SPEAR

My principal informants on elephant hunting techniques shared similar techniques to explain how they succeeded in killing several elephants with spears. I will begin by describing what my informants consider the most accomplished method, what I call the "under-belly technique", then the "anus technique" and finally the "Achilles tendon technique" —before briefly mentioning some other methods reported to me by others, or found in ethnographies of BaYaka. Stones are rare in the BaYaka region, prompting me to ask what people did before they had metal. My elder informants told me that their ancestors used smashed tusk shards as blades for both hunting and honey collecting.

All the key techniques require the *tuma* to approach so close that they can directly thrust their spear into the elephant. The technique considered the quickest and most elegant method is the "under-belly technique". To accomplish this requires a *tuma* to be highly skilled in magical and practical techniques. Once close to the elephant, with wind in his face and sun behind him, the *tuma* uses his *mondaanga* braclet to shift the animal into a suitable position that provides access to the flanks on both sides. Confident that his *moombi* paste makes him invisible, that the elephant dung masks his smell, his main concern is to be silent as he approaches. Ideally the elephant is resting or eating as he moves. Coming up beside it just in front of the hind leg, the *tuma* powerfully thrusts the spear into the abdomen, seeking to force it up behind the rib cage towards the heart and other vital organs. Pushing the spear as deep as possible, the *tuma* ducks under the elephant's belly to escape on the other side and run into the undergrowth. The elephant on feeling the spear penetrate, turns its head to see what has caused such pain, using its trunk it finds the protruding spear shaft and seeks to extract it. This distraction provides the *tuma* with time to safely escape on the other side. The spear's angle is awkward for the trunk to grasp and pull out. If the spear is well placed the elephant in effect kills itself by lacerating its internal organs in its efforts to remove the spear. The *tuma* waits quietly nearby for the elephant to collapse.

The anus technique is used when it is not possible to safely run under the belly. This is often due to the elephant being encountered in deep mud, or in an open space without cover such as a salt lick, or conversely in thick undergrowth, or when the configuration of undergrowth and trees around the elephant block access to its underside. Again wind in the face and sun behind, but now the *tuma* need not risk getting close to the head and trunk, but rather approaches from the rear. If necessary, he uses the *mondaanga* bracelet to move the elephant. The key is to have a clear approach to the anus and an escape route on the opposing side. The *tuma* gets up next to the elephant's backside and thrusts his spear deep inside the elephant using the soft tissue around the anus as his path into the abdomen. If possible he ends with a sideways motion that seeks to do as much internal damage as possible. He then flees to avoid the wrath of the wounded elephant. The internal bleeding will take some time to kill the elephant so the *tuma* and other hunters track the elephant secretly from a distance. It is important not to be noticed by the elephant or it may flee with greater speed and move further. When done correctly the elephant dies quickly.

The Achilles tendon technique may be used in conjunction with the above techniques or as the principle technique. It involves slicing the Achilles tendon to immobilize the elephant so that it can be speared until killed. While this is easier in the first stage —slicing the tendon— killing the elephant afterwards is a very dangerous procedure. An immobile wounded elephant is a formidable opponent and the *tuma* will call others to come and help. Elder men build fires and bring their small metal mushroom-shaped anvils, younger men encircle the elephant, confusing it with mock charges so that it reaches to one side so that those on the opposing side can quickly charge in to thrust their spear. The elephant responds with increasing fury and pulls out the spears. Due to the damage the spears receive —often being twisted by bones or during withdrawal, the elder men heat them in the fire and rework them to straighten the blade again. As they are fixed, younger men take them to launch further attacks. The one account of such a hunt I was told emphasized the role of a man considered mad (*djomwa*), who had violent tendencies when suffering a mental crisis. I had often puzzled that he was not ostracized following some of his more notorious episodes. But it became clear to me, as this story was told, that his psychopathic tendencies were welcome and of great value to the group at such times. When the immobilized elephant was at its most furious and dangerous, it was this man that continued thrusting in the spears with fury and efficacy to finally kill it.

While the above techniques are those I was told about by my informants, Bahuchet describes a technique involving slicing the femoral artery in the hind leg to cause massive hemorrhaging. My informants considered this a clever technique. Bahuchet (1985: p. 242) also includes descriptions of a technique based on pushing the base of the spear into the ground when faced with a charging elephant so that it impales itself. My informants were skeptical of this method. They knew the technique as effective when being charged by a gorilla, but the weight, momentum and reach of an elephant's trunk made this technique seem implausibly risky. Likewise, Bahuchet's (1985: p. 243) report that it is easy to spear a standing elephant was perplexing.

17.8 CONCLUSIONS

The similarities between the BaYaka and Mbuti techniques for hunting forest elephants as described by Ichikawa (this volume) are striking. Elephant hunters are called "*tuma*" among Mbuti (Bantu language speakers), Baka (Ubangian language speakers) and BaYaka (Bantu language speakers). Mbuti and BaYaka share similar spear hunting techniques —the abdominal thrusting technique and the tendon technique. Echoing the historical reports of invisibility quoted in opening the chapter, both use versions of what BaYaka call *moombi* paste to become invisible. Both use the occasion of feasting on elephant for festive celebration and consume all parts of the animal aside from bone and stomach contents. Additionally, Ichikawa's (this volume) and Yasuoka's (this volume) observations on the frequency of elephant hunting among Mbuti and Baka, of an average of about one every six months, is likely similar to rates in Northern Congo before protected area conservation. Conservation efforts to control elephant hunting began in early 1990s. During my fieldwork between 1994 and 1997 three elephants (average of one per year) were killed near where we camped.

Although sharing a similar forest habitat, BaYaka and Mbuti live over 1000 kilometers apart, speak different languages, and according to genetic studies last lived together over 25,000 years ago (Verdu et al., 2009). Their similar adaptations to forest living are demonstrated by elements of shared material culture —the form and materials used for forest huts, or honey collecting, for instance; and in ritual their shared distinctive polyphonic singing style used to play with forest spirits. These are likely to be optimum adaptations to this forest environment (Lewis, 2016). Are their similar elephant hunting practices and shared label of *tuma* part of this ancient complex of optimum adaptations to hunting and gathering in the Congo Basin? Or are these similarities in elephant hunting the product of diffusion as early traders sought ivory in new places during the Atlantic Trade or colonial period and used the vocabulary they were familiar with, or shared hunting techniques they knew from elsewhere when encountering new groups in other parts of the forest?[3]

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[3] The Hadza, savannah hunter-gatherers of Tanzania, say they have never hunted elephant (James Woodburn, pers. comm., 2010), explaining that the herds are so large and that they are too difficult to approach safely. Forest elephants tend to live in small herds, and the cover provided by trees and undergrowth may partially account for the greater ease and safety when hunting forest elephants.

An elderly Mbuti *tuma* said to Ichikawa that they did not hunt elephant often in the past, but once ivory traders came they began hunting them more (Ichikawa, this volume). It is certainly true that since world markets became interested in forest products, ivory has been of special importance, and as mentioned in the introduction, BaYaka people appear to have been key providers of ivory since the beginning. But is this what pushed Pygmies to hunt elephant? My Mbendjele BaYaka informants were clear that men have always hunted elephant. In their origin myth, when men and women lived apart, men hunted elephants, and in some male versions of the myth, it is when an elder man decided to go elephant hunting alone that men first discovered the women, and the events that lead to the establishment of contemporary society, such as women's gift of *Ejɛngi* to the men, occurred.

The cultural centrality of elephant hunting for BaYaka gender relations, myth, religion, ritual and feasting is striking. In particular, the recognition of the importance of women in *Yele* promoting "a woman's hunt", by finding the elephant, thrusting in the first "spear", then inciting the men to go on such hunts, maintaining sufficient social pressure on the men to complete the process, and as seen in Benasongo's exile – to punish men that do not follow the rules. The ritual complex in which elephant hunting is embedded divides responsibility for success, and the opportunity for men to use killing elephants to claim prestige or status, since it is women who are ultimately responsible for the elephant's death. As Benasongo's case illustrates, men who ignore the importance of women's role, and hunt or boast too much can be ostracized by the women refusing to collect, share and even cook that hunter's meat. Given the importance of elephant fats in supporting increasing encephalization among our ancestors (Agam and Barkai, 2018), could these be modern instantiations of the kinds of tactics employed by women in the deep past to address the reproductive burdens of birthing progressively immature babies by securing male hunting labor?

A further element potentially of interest in hypothesizing about the past is the importance of *moadjo* in representing and sharing knowledge about animal minds to other people. The information communicated concerning the prey's motives and intentions during these pantomimes is complex and substantial, and depends on anthropomorphizing animals. As *tuma* reenact past hunts during *Bula*, they also offer explanations of elephant behavior often expressed in terms of human emotions and reasoning ("he was angry because he could smell me but not see me"). While such anthropomorphisation of animal intentions is often dismissed as projection rather than insight into animal minds, when *tuma* do so they are remarkably accurate in predicting the animal's behavior. With intimate and detailed knowledge of an animal's behavioral ecology, their musing concerning motivations, emotions or intentions are often accurate. In the case of elephant hunters, their lives depend on it.

BaYaka have made such storytelling an art they call *gano*. This distinctive multimodal style of telling sung fables (*gano*) engages the whole community in reenacting events. Participants transform themselves into mythical animal and human characters to relive for themselves the events recounted. In *gano*, animals are personified with distinctive character traits that BaYaka attribute to those animals as a species. In Knight and Lewis (2017) we argue that hunters' storytelling needs are likely to have been an important stimulus for the evolution of language. The pantomimic style and acoustic mimicry of events shared between *gano*, *besimɛ* and *moadjo* is indicative of what such early multi-modal communication could have been like, and how much more informative they are than plain speech.

While such knowledge of elephants and other animals is important, having the courage to go out and take one of these fearsome creatures on in a fight to the death is vital. This accounts for the substantial time and energy spent on ritualizing the hunt and for the sophistication of magical objects seen as a key part of the *tuma*'s hunting kit. It seems that the belief that one can escape, can move the elephant into a better position, can become invisible and so on, are what it takes for men to have the courage to get so close to the elephant that they can touch it. Together, these elements of ritual and practical knowledge are what give men the confidence to take on the formidable and dangerous elephant as prey. Daring to try may be as important as knowing how.

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18. ELEPHANT HUNTING BY THE MBUTI HUNTER-GATHERERS IN THE EASTERN CONGO BASIN

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ABSTRACT

Mbuti hunter-gatherers in the Ituri forest of the eastern Congo Basin have been known as elephant hunters since the colonial period. They provided the colonial agents with ivory, and supplied meat for local mining and plantation workers, as well as for their own consumption. In this study, I present ethnography of the Mbuti elephant (*Loxodonta cyclotis*) hunting practiced during my field research in the 1970s and 1980s, including the description of hunting method with spears, hunting party and success rate, distribution of meat, and festive nature of meat consumption. Although the elephant hunting provided almost as much meat (6–7 tonnes of live weight/year for a group of 50 people) like other types of hunting aiming at medium to small-sized antelopes and monkeys, the success rate of the elephant hunt was very low. In contrast to the stable yields of meat from hunting for smaller animals, elephant hunting was successful only a few times a year, mainly by skilled hunters called *batuma*, with their courage and luck. For such unstable nature, with its low success rate and huge quantity of meat supply in a successful hunt, elephant hunting provided the Mbuti with exciting experiences with rich ritual performances and festive meat consumption, and gave a strong accent to the otherwise monotonous hunting life in the forest.

18.1 INTRODUCTION

African forest elephant (*Loxodonta cyclotis*) hunting by the Mbuti in the Ituri Forest of the Democratic Republic of Congo (former Zaire) has already been described by several authors. Paul Schebesta, a Catholic Father and ethnologist, described briefly elephant hunting carried out by the Mbuti (Schebesta, 1933). Putnam (1948), who spent many years in Epulu, central Ituri, gave a four-page description on elephant hunting and associating rituals. Turnbull (1965) also described it briefly, though it seems he did not observe directly the elephant hunt. Coon (1972) gave accounts of elephant hunting methods by the Akoa in Gabon, Efe and Mbuti in Congo, citing the

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works of Trilles (1932) and Putnam (1948). More recently, Duffy (1984) gave an on the spot observation of hunting and butchering of an elephant by the Mbuti, in his book of "Children of the Forest". Harako (1976) and Bahuchet (1985) reported also on the elephant hunting by the Mbuti and Aka Pygmies of Central Africa. In a study of prehistoric and contemporary mammoth and elephant hunting, Agam and Barkai (2018) reviewed various elephant hunting methods employed by contemporary hunter-gatherers. There is also a film on elephant hunting by the Mbuti in Ituri, taken by Japanese television team (NTV, 1972). However, most of these contain only brief descriptions of hunting methods, and ritual and festive characteristics of elephant hunting and meat consumption. Only one example, witnessed by Duffy, was based on the observation of actual cases of successful hunt. I will mainly focus here on the hunting method, success rate, and meat distribution patterns, and festive nature of meat consumption among the Mbuti, which I studied during my fieldwork in the Ituri Forest of the Democratic Republic of Congo from 1974 to 1975 and from 1980 to 1981.

The Ituri forest is situated in the northeastern part of the present-day Democratic Republic of Congo (DRC, former Zaire) and covers the area of approximately 100,000 km^2. The vegetation is dominated by evergreen dense forests with closed canopy, consisting of Caesalpiniaceae, in particular, mixed forests of *Julbernardia seretti* and *Cynometra alexandri*, and single-dominant forest of *mbau*, *Gilbertiodendron dewevrei* (Itani, 1974; Harako, 1976). There are about 30,000 to 40,000 hunter-gatherer people, called Mbuti, Efe and other names in the region (Harako, 1976). The Mbuti belong to a Bantu-speaking group and live in the central, southern and western parts of the forest, whereas the Efe are Sudanic-speakers, living in the northern and eastern parts of the forest. Both groups have been in close economic and social relationships with the neighboring agricultural groups who speak similar languages with the respective hunter-gatherer groups.

The principal hunting methods of the Mbuti in central Ituri are collective net hunting, bow-and-arrow hunting, and spear hunting. Unlike their neighboring agriculturalists and Pygmy groups in other regions, they rarely used snares in the 1970's and 1980's when I conducted my research. Net hunting is adapted to the forest environment with poor visibility, and carried out for capturing small- to medium-sized animals, in particular forest duikers (weighing from 3–25 kg), which are driven from the bush toward the net enclosure. Bow-and-arrow hunting aims at hunting arboreal monkeys, which are shot with poisoned arrows. The arrow poison is made from various forest plants, which are mixed and pounded, and the black liquid squeezed from the plants is applied to the arrows made of raffia palm axes. With spears, they aim at hunting larger-sized animals, such as bush pigs, giant forest hogs, buffaloes and elephants (Harako, 1976). The major hunting methods of the Efe in northern Ituri are bow-and-arrow hunting, in particular collective hunting called *mota*, which is also adapted to the dense forest environment. It aims at shooting duikers driven from the bush with arrows with iron tips. Solitary hunting is also common for shooting monkeys in a tree with poisoned arrows. Spear hunting is carried out for larger targets. While both the Mbuti and Efe had formerly used spears borrowed from the Bantu or Sudanic agricultural villagers, who had become the owner of the animals killed with the spears, most of the Mbuti and Efe hunters had their own spears when the research was conducted in 1970s.

We do not know when the Mbuti started elephant hunting. According to the information given by a British ex-prisoner of Portuguese, elephant hunting had already been practiced by the hunter-gatherers in the present-day Gabon in early 1600's (Schlichter, 1892; Kitanishi, 2012). Dapper (1686; cited in Kitanishi, 2012) also mentioned about the "dwarfs", who hunted elephants and traded ivory. In a study of central African history, Klieman (2003) wrote that elephant ivory had comprised one of the important items for the Atlantic trade since the contacts with European in the 17th century. In the Ituri forest of DRC, which is far from the Atlantic coast, elephant hunting probably had not become a major hunting practice until relatively recently. An old Mbuti man once told me that they had formerly hunted mainly bush pigs and other smaller mammals with spears, and that they began hunting elephants frequently as the demands for ivory increased. Probably, it was during the time of arrival of Arab traders in the 19th century when the Mbuti started elephant hunting actively. It was then accelerated under the Belgian rule. The travelers to this region in late 19th century mentioned briefly on the elephant hunting by various "Pygmy" groups (Stanley, 1890; Cassati, 1891; Parke, 1891).

It is understandable that they had not attempted at elephant hunting frequently in former days, because it was a dangerous work [as reported also by Lewis (this volume)], whereas there were other, smaller animals, which could be easily hunted in the forest. I was informed that a Mbuti man of the group I studied had been killed by an elephant during the hunt. Schebesta (1933, 1936b) also reported an example of a Mbuti hunter killed by an elephant, and another example of serious injury. He then expressed his concern about the Mbuti hunters, who were driven to hunt elephants by the request of a Bantu chief seeking for ivory.

However, as elephant hunting became popular, the motivation for it was gradually internalized within the Mbuti themselves. Elephant hunting risked a hunter's life, whereas it provided a huge quantity of meat when successful. As such, elephant hunting became a practice associated with rich ritual performances and social significance, as described by various authors (e.g., Trilles, 1932; Schebesta, 1936a; Putnam, 1948; Turnbull, 1965; Harako, 1976; Lewis, 2002). The success of elephant hunting may also have given a sense of accomplishment to the hunter, even though he could not gain prestige in the egalitarian Mbuti society.

In early 20th century, the Mbuti became known to Western society as brave elephant hunters, who hunt the largest terrestrial mammals with spears, sometimes a single hunter by himself. Ivory was then one of the major export items from the forests in this region, together with wild rubber, which was often called "red rubber" for the bloody nature of quota system (Stengers and Vansina, 1985; Jewsiewicki, 1983; Hochschild, 1998). According to the Mbuti elders, they moved to the forest near the trading posts, and hunted elephants actively. When they killed an elephant, they brought the tusks to their Bantu patrons, who sold them to the traders. The Mbuti then obtained salt, tobacco, clothes and agricultural food from the villagers. The photograph taken at Mawambi trading post (now deserted) on the right bank of Ituri River illustrates the scene of weighing the rubber and ivory. It was taken by a British explorer, Captain Powell-Cotton, on his honeymoon journey to the Ituri Forest (Powell-Cotton, 1907).

18.2 HUNTING METHOD

Hunting elephants is a difficult task. A photograph showing elephants stuck in a mud pool may give us an idea of how elephants were killed in prehistoric times. The elephants cannot get out of the pool by themselves, because of their heavy weight. The prehistoric hunters may have hunted the elephants that were similarly stuck in the muds. Du Chaillu (1867) described the elephant hunting by the Fang, Bantu–speaking farmers in equatorial Africa. They made liana tangles on the elephant trails in the forest. When an elephant was entangled, it was killed with spear traps, called *hanou*, falling logs with spear points, hung high up in the air. A similar falling spear traps were also used by the Bantu agriculturalists in the Ituri forest of Congo. Babali hunters set a heavy spear trap, with an iron head of one foot long and a thick shaft of 6–9 feet, suspended in the air at a height of 15 feet (Schebesta, 1936a). A different type of falling spear trap was once used by the Suiei Dorobo hunters in northern Kenya. The trap is called *lkerenget*, and the poison made from the root of *Acokanthera* (called *morijoi*), a shrub genus belonging to Apocynaceae, is applied to a small spear point. The Dorobo

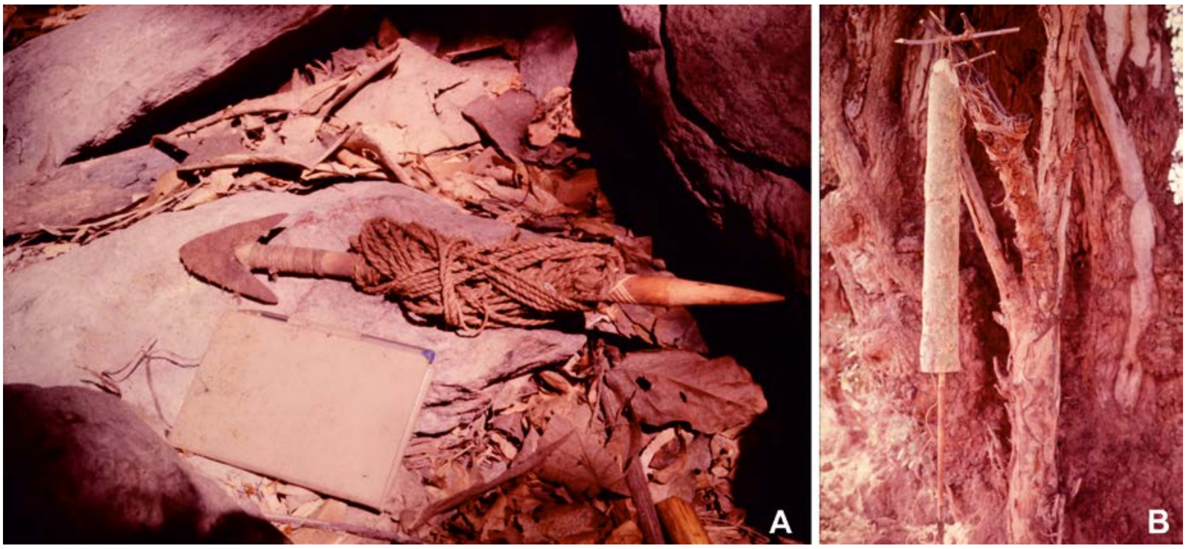

Figure 18.1: A, *Lkerenget*, falling spear; **B,** *Lkerenget* trap set in the air. Photos by M. Ichikawa.

hunters set the trap on the elephant's trail. A heavy weight of *Commiphora* wood, with a poisoned iron spear, is hung in the air with a liana cord, over the branch of a high tree. The cord is then set across the elephant's trail. When an elephant pushes the cord, the trigger is released and the poisoned spear point with heavy weight falls on the back of the elephant (Fig. 18.1a, b).

The Mbuti hunters in the Ituri forest of Congo Basin, however, did not use these traps when I stayed there in 1970s and 1980s. They neither used pit falls or trenches, which had been used by their neighboring Babali and other Bantu-speaking cultivators (Schebesta, 1936a). Elephants were always hunted with spears by the Mbuti. According to Turnbull (1965), when metal spears had not been available, the Mbuti asserted that they had hunted elephants with fire-hardened wooden spears. When I asked the Mbuti hunters about this, they said that it was impossible. I think it is extremely difficult to pierce the elephant thick skins with wooden spears, unless the elephant comes to a complete stop, and waiting for a hunter to spear, for example extremely exhausted by enduring pursuit or stuck in a mud pool.

The Mbuti in central and southern part of Ituri, who speak Bantu language, use spears with extremely large spearhead and try to stab the lower abdomen of the elephants (Fig. 18.2a). On the other hand, the Efe (Sudanic-speaking group) in northern Ituri use smaller spears and try to stab the backside of knees to immobilize the elephant (Fig. 18.2b). Both techniques are effective, because an elephant with an injured hind leg cannot support its heavy weight to walk or run fast. Otherwise, the contents of intestines come out when the spear penetrates the elephant's abdomen properly, which soon leads to peritonitis.

The spearhead of the Mbuti is 8–10 cm wide and 40–50 cm long, and attached to a strong wooden shaft. The blade is razor-sharpened with a stone. The spears are thrown for hunting buffaloes, bush pigs and other smaller animals from a distance of several meters. For elephants, however, they approach close enough to the elephants and try to stab the softer part of the lower abdomen.

Elephant hunting is carried out either by a large group of hunters or by a few hunters, but there is always at least one experienced specialist called *mtuma* (or *batuma* in plural form), which is a common word throughout the central African Pygmy societies, and suggests wide-spread practice of elephant hunting in the central African forests. While a large group may be formed for hunting elephants, which happen to be found near the forest camp, elephant hunting in the Teturi area, where I conducted my research, was mostly carried out in a remote forest by a small number of hunters, some-

Figure 18.2: A, spear used by the Mbuti hunters; **B,** spears used by the Efe hunters. Photos by M. Ichikawa.

times even by a single hunter (*mtuma*). A *mtuma* is often accompanied by one or two young men, his younger brother, son or nephew, as apprentice or assistant doing daily chores. These young men usually do not attempt to spear an elephant. The Mbuti in my study area did not use dogs for hunting elephants. For hunting other animals, such as buffaloes and bush pigs, dogs play important roles in tracking the target animals, stopping them when they catch up, and distracting the animal's attention from hunters. However, the Mbuti say dogs are useless for hunting elephants, because the elephants easily notice the presence of dogs and hunters, which makes the approach extremely difficult.

The hunters go into the interior forest to search for elephants, carrying with them spears, ax, fire brand, but often without food. They search for fresh traces of elephants for several days, living on wild honey extracted from natural hives, wild yams and other vegetable food in the forest, and sleep by the fire made of the brand, which was carefully protected from dying out during the search.

Elephants frequently visit muddy marshes, called *lako* (muddy pool) or *potolo* (marshland), where the hunters often find fresh traces of elephants. If they find there fresh trace of elephants, called *maikpada*, they carefully track the animals, approach the animal from leeward while it is feeding. If the hunter successfully gets under the abdomen, he thrusts the spear through, and run away quickly and hides himself behind a big tree or squat down and stay still, so that the elephant with poor eyesight may not see him. The young men accompanying the *mtuma* try to distract the attention of the elephant from a safe place, particularly when the hunt fails.

Once the spearhead enters deep into the abdominal cavity, it cuts the intestines as the fright-

Case	Date	Number of participants	Number of days spent hunting	Catch
1	March 1973	17	1	1 bushpig
2	April 1973	3	1	1 bushpig
3	May 1973	17	1	1 buffalo
4	May 1973	17	1	1 buffalo
5	June 1973	group*	1	0
6	June 1973	group*	1	0
7	June 1973	3	1	0
8	June 1973	1	1	0
9	June 1973	1	1	0
10	June 1973	3	1	1 okapi

Table 18.1: Record of elephant hunting at Lolwa, central Ituri Forest (data from Harako, 1976); *, the number of participants is unknown.

ened elephant dashes in the bush. As the spear shaft strikes the trees and branches, the razor sharp blade in the abdomen further cut the intestines. The elephant quickly loose power when the contents of intestines come out. The hunter tracks the animal to give a finishing stab. It takes several hours to a day or two, from the first stab to the final kill. If the spear does not enter the body deep enough, for example, less than 10 cm deep, and no sign of fatal damage (blood or contents of intestines) are found, they would not pursue the target.

However, it is more often the case that hunters are noticed by elephants before approaching close enough and the elephant runs away. When I accompanied the Mbuti hunters in elephant hunting, they were very sensitive about the scent of my clothes. When the target got away, they often complained about my clothes, saying that the elephant noticed the smell of soap of my clothes, even when I had been wearing the same clothes for more than a week after washing. They often smear their body with muds, or elephant dung, so that the elephant may not notice their smell. They also smear the charcoals of certain forest plants, which they say make their body invisible to the elephants. The charcoals are also rubbed into incisions made on the leg, which, they say, enables them to run fast in the forest. However, even when they could get close to the elephant, the hunter may fail to stab the elephant, or the spear may not enter into the body deep enough.

18.3 SUCCESS RATE

According to Harako (1976), who reported on spear hunting at Lolwa, central Ituri region, elephant hunting was conducted either in large or small groups. A large hunting group was comprised of two components; first spear givers composed of adult hunters, including *batuma*, and assisting group, or apprentices of young hunters, who carry food packed with leaves, called *musaba*, leftovers of breakfast, to eat on the way. During the five-month research by Harako in 1973, a total of ten attempts, of which five were by large groups of more than 10 men, were made. The results were two kills each of bush pigs and buffaloes, and one of okapi, but they could not kill their major target, an elephant (Table 18.1). When they encounter other animals while searching for elephants, they will of course, try to hunt them.

During my research for a total of 15 months from 1974 to 1975, and from 1980 to 1981, elephant hunting took place in small groups of two to four hunters, always led by an experienced elephant hunter (*mtuma*). Out of six hunts attempted during ten months from 1974 to 1975, they succeeded in killing an elephant only once,

Case	Date	Number of participants	Number of days spent hunting	Catch
1	October 1974	4	3	elephant
2	November 1974	3	4	dwarf crocodile
3	December 1974	3	6	0
4	January 1974	4	2	0
5	February 1975	3	3	okapi (deceased)
6	February 1975	3	2	0
7	December 1980	3	2	elephant

Table 18.2: Elephant hunting record from August 1974 to February 1975 in Teturi area (data from Ichikawa, 1982).

though smaller animals were killed on two occasions (Table 18.2). The success rate in this period is, therefore, one for six attempts, or, one elephant kill per 60–70 hunter-days of hunting efforts. According to the Mbuti interviewed in 1980, during 25 months from August 1978 (when colleagues of mine visited the same group) to September, 1980 (when I visited them again), a total of four elephants had been killed at different parts of the forest, all by the same *mtuma*, who killed one in December, 1980. For the Efe in northern Ituri forest, Terashima (1983) reported that during his six months research from 1978 to 1979, two hunting groups attempted elephant hunting for several times, and killed two elephants. Probably, the average kill by a band is around one elephant for half a year, because elephant hunting is not practiced regularly, but only occasionally. When an elephant is killed, a huge quantity of meat becomes available, but it is rather a rare occasion, and not reliable for daily subsistence. In December 1980, during my second research, a young elephant was killed by a well-known elephant hunter.

18.4 DISTRIBUTION OF MEAT

When the elephant was killed, the hunters returned to the camp, beating the buttress root of a large tree on the way to inform the success of the hunt. When the *mtuma* hunter arrived at the camp, carrying his broken spear on the shoulder, which was a sign of success, the people in the camp shouted with joy. The entire group immediately moved to the site of the kill (Fig. 18.3). On arriving at the site, men started dismembering the carcass, cutting and dividing the meat. There was no "skin biting ceremony" (that is, to let a small boy bite the membrane under the skin and bathe the sprouting putrefied contents of intestines) as reported by Putnam (1948). Duffy (1984), who witnessed dismembering of an elephant at the killing site, also stated that there was no such ceremony. A video taken by Japanese television crew showed a Mbuti hunter (not a boy, however) biting the white subcutaneous tissue of an elephant (NAV, 1972), but the meaning of this biting was not clear.

The elephant formally belongs to the owner of the spear, which made the first fatal stab, most probably the *mtuma*. However, this ownership is only nominal. Everyone can cut and take the meat as they like, except for special parts to be allocated to specific members of the group. In the group I studied, the special parts, numbered in Figure 18.4, are eaten only by the members of the Bapuera patrilineal clan, which form the majority of the group. These parts are either highly prized parts, such as fatty parts, heart, liver and kidneys, the parts with a special taste or texture, or with some ritual meaning such as the trunk tip and the tail. As most forest-mammals, except bush pigs in the fruiting season, are generally low in fat, fatty parts are highly valued[1]. The foot above the planter

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[1] While they said they would extract marrow (white fatty substance) from bones, I did not observe them to eat the bone marrow of the elephant.

Figure 18.3: A young elephant whose left-side lower abdomen was pierced with a spear. Photo by M. Ichikawa.

has white fatty cushion, which is much favored by the Mbuti. The liver, heart and kidneys are rich in vitamin and minerals. The trunk tip and tail are the leading and trailing parts, and symbolize the entire animal, and are taken by a man called *bulumusa*, meaning "the first to pull", or the one who first departs from the camp for collective hunting, and makes a hunting fire before other members arrive at the hunting ground. This hunting fire, called "*kungya*", literally meaning "to converse", is made for communicating with the "Apakumandura" (master of forest), and for asking permission and success of hunting. The *bulumusa* man also plays an important role in the *molimo* spirit ritual performance. These special parts are shown in Figure 18.4, with the names of parts and the recipients of Bapuera clan. The fatty meat of foot (planters), which has special taste and texture, are cut into pieces, and shared among the Bapuera clan members.

They cut and take as much meat as they like (Fig. 18.5). The man who obtained the largest amount, 50 kg after boiled and half-dried, was a paternal cousin of the *mtuma* hunter, who killed the elephant, whereas the *mtuma* hunter himself took 44 kg (Table 18.3). More than a half tonne of meat was obtained from the elephant, and this was enough for about 40 camp members to have meat feast for a week, even when part of the meat was brought to the village for exchanging with the Bantu cultivators for cassava, plantain and other agricultural food. In this way, elephant hunting provides them with a huge quantity of meat at a time. Moreover, it provides a large quantity of much favored fats, which cannot be obtained from

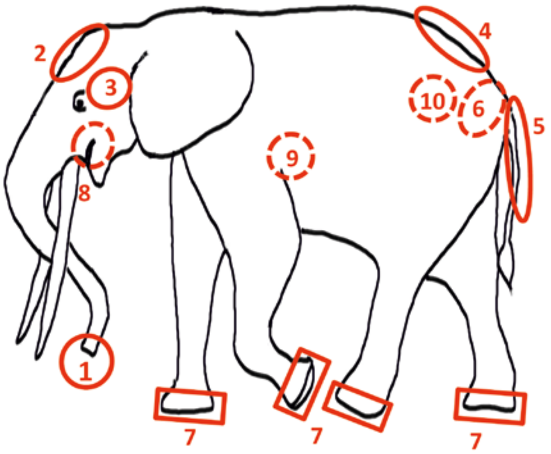

Figure 18.4: Elephant parts taken by the specific members of the Bapuera clan. 1, *sesi*: trunk tip; 2, *tinapata*: forehead; 3, *tesiyo*: front of ears; 4, *ekiliti*: loin; 5, *tinakondo*: tails; 6, *esuata*: meat inside the pelvis; 7, *etindi*: foot (above the plantar); 8, *edaka*: tongue; 9: *bukameema*: heart; 10, *bagbe*: kidney. Dashed lines indicate internal parts and organs.

Figure 18.5: Butchering the carcass. Photo by M. Ichikawa.

Members	Relationship to tuma	Special parts taken	Weight of meat taken
Bapuera clan members			
A	*tuma* hunter	6, 4	44
B	brother	10	33
C	brother	4	37
D	brother, *bulumusa*	1,3, 5	40
E*	brother	4	15
F	brother		?
G	paternal cousin	9, 4	35
H		8	50
I*	paternal cousin	3	?
Other clan members			
J*	cross-cousin		8
K	cross-cousin		21.5
L*	cross-cousin		21

Table 18.3: Weight of meat (in kg, partly dried) obtained by individuals (December 1980). Underlined members (A, C and J) participated in the hunt; the numbering of the elephant parts corresponds to Figure 18.4; the planters of foot (7) are split into two pieces and shared among the Bapuera clan members; *, staying alone without family.

other forest animals, except bush pigs. The problem is that, it is unstable and successful only a few times a year.

All the camp members enjoyed the feast of elephant meat. Before the hunt, ritual performances were held at night for hunting success, with intensive singing and dancing. *Butuma* (elephant hunting) songs were sung by adult men with beating of *banja*, a pair of wooden sticks torn from half to the end, and women danced in a circle. However, unlike the previous reports, there was no ceremonial performance after the successful hunt in this case, though the feast continued several days after the hunt. All the parts, except bones, teeth,

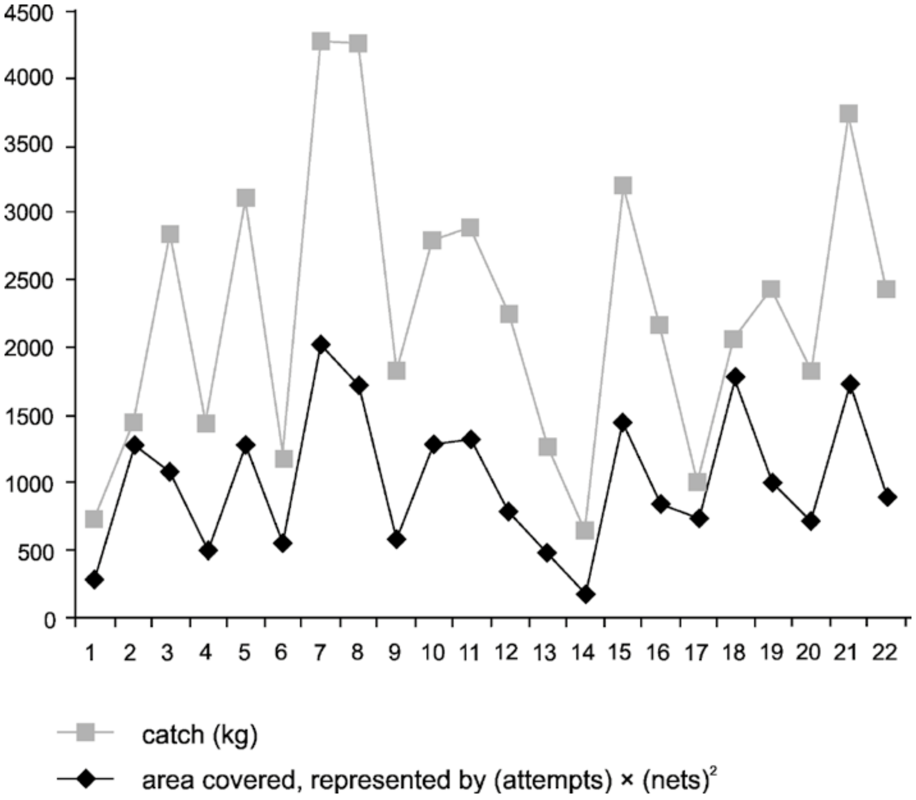

Figure 18.6: Hunting efforts and catch in net hunting. Hunting effort is shown in black lines and catch in gray lines on the vertical axis. The effort is represented by the number of attempts (net casts) × (net length in meters)^2. The amount of catch is shown in kg x 100. Horizontal axis shows the hunting days, from 1st to 22nd day.

and contents of digestive tracts, were consumed. Even skins were cut into thin strips and eaten, after cooked for a long time. If there had been cassava leaves brought from the village, they would have been cooked with elephant skins, to make one of the favorite dishes of the Mbuti. The ivory belongs to the owner, i.e., *mtuma* hunter in this case. He brought it to a Bantu farmer, who probably sold it to a trader secretly, because ivory trade without license was illegal at the time of my research.

18.5 DISCUSSION AND CONCLUSIONS: COMPARISON WITH NET HUNTING

Compared with such an unstable hunting for elephants, the Mbuti's daily hunting with nets provides them with much more stable catch. It aims at forest duikers, weighing from 5 to 25 kg. Usually ten to fifteen nets are combined to make a large semicircle. Women and children beat the bush to drive the animals toward the nets. When an animal is entangled in the net, the man hiding by the net seizes the animal and kills it with a stick or spear. One hunting attempt (consisting of setting nets, driving the animals, killing the animals entangled in the nets, removing the nets and moving to the next hunting ground) takes about an hour, and usually five to ten attempts are made in a day.

The daily catch from net hunting is strongly correlated to their hunting effort, as shown in Figure 18.6. The more hunting effort is made, the more hunting yields they get. Hunting effort in this case is estimated by the total area covered by the nets in the day's hunt, which in turn is represented by (number of attempts = net casts) × (total net lengths used in the day's hunt)^2. The meat distribution patterns are also contrastive. In the case of net hunting, the owner of the animals must distribute the parts to other participants, depending on the roles they have played in the hunt. The hunter, who uses other's net is given a hind leg, while the woman who carries the carcass to the camp takes one of the front legs. The

	NET HUNTING	ELEPHANT HUNTING
catch	6–7 tonnes/year, small and stable	5–6 tonnes/year, large but unstable
participants	ordinary men and women	specialists (*batuma*)
meat sharing	first obligatory, followed by voluntary	share with equal access, except of specific parts
ritual performances	rare	special performances
songs	yes but infrequent	special songs by men
feast	no	yes

Table 18.4: Comparison between net hunting and elephant hunting.

one who assists to kill the animal entangled in the net takes the part of the chest called *esosi*, while the man who first depart the camp and make a hunting fire before the hunt starts takes the lower ribs, called *seka* of medium-sized duikers and the heads of blue duikers. Such distribution is formal and obligatory, and we call it "first distribution", which is then followed by voluntary, secondary distribution from those who have to those who haven't the meat. The distribution of elephant meat is quite different. Certain parts are given to the specific individuals, regardless of the role played in the hunt, whereas other parts are shared freely among the camp members as they butchered the carcass.

As has been often reported, elephant hunting has a heavy cultural load, or, cultural meanings. Before the hunt, special ritual is performed, with singing and dancing. The men sing special songs for *butuma*, elephant hunting songs, and women dance. For net hunting, no special skill/technique is necessary. Any adult men and even boys of lower teenagers handle the nets, and women and children participate also as beaters. By contrast, elephant hunting is performed by experienced adult hunters, with a master hunter (*mtuma*) playing a central role. The *mtuma* exerts leadership in hunting, based on his skills, knowledge, and courage. He has developed the capacity for *mtuma* through accompanying his predecessor *mtuma*, often his father or uncle. While his authority is restricted to the activities related to elephant hunting, it is still unusual in an otherwise egalitarian society.

Figure 18.7: Dwarf kingfisher, "bird of elephants". Photo by M. Ichikawa.

The amounts of meat obtained in a year from two hunting methods are almost the same, 6–7 tonnes per annum for a group of 40–50 members. However, the stability of meat yield is very much different. The elephant hunting fails in most cases, but when it is successful, a huge quantity of meat is obtained at a time. Meat distribution pattern is also different; elephant meat is shared almost freely among the camp members, except for certain parts, and joyful feast follows after the successful hunt.

In these ways, elephant hunting makes a strong accent to an otherwise monotonous daily life with collective net hunting, which ensures regular and stable supply of meat, but only in a small quantity (Table 18.4).

How about the image of elephants? Elephants are the biggest game in the region, and provide them with highly prized meat in large quantities. The Mbuti say the elephant meat is the best of the forest animals, mainly because of the quantity of meat provided at a time. However, they also know that elephants are dangerous animals, which may kill hunters, as mentioned before. The Mbuti women and children are afraid of an unexpected encounter with elephants in the forest. They are always excited when they are talking or discussing about their experiences with elephants. However, in the Mbuti folktales, elephants are not considered the "greatest" animal. According to the Mbuti, the chief or king of the forest animals is a small creature, the land tortoise, called *koti*. The reason why land tortoises are greater than elephants is not clear, but in a Mbuti folktale, "the land tortoise commands the elephants on their back during the march of forest animals".

The Mbuti believe that each of the major animal species (mainly mammals) in the forest is associated with a specific species of birds, which warn and alert to their associating animals of approaching danger. Alternatively, on the contrary, these birds also inform human hunters of the location of their associating animals. A smaller type of hornbills, called "*kohekohe*", is the bird of elephants, and said to be often found near the elephants. Also, bird species called *mangamako*, dwarf kingfishers (Fig. 18.7) and marakite kingfishers, smallest types of kingfishers in the forest, are said to be associated with the elephants, and show the direction or location of elephants with their conspicuous red beak (Ichikawa, 1998). It is interesting to see that the largest animals are subject to, or associated with such small animal species in the forest.

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19. SHARING ELEPHANT MEAT AND THE ONTOLOGY OF HUNTING AMONG THE BAKA HUNTER-GATHERERS IN THE CONGO BASIN RAINFOREST

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ABSTRACT

Among the Baka hunter-gatherers, the sharing of elephant meat is associated with a taboo that forbids the hunter who killed an elephant from eating its meat. Previous studies examined the taboo in relation to the paradox of egalitarians: the impossibility of dual equality, that is, on economic and social grounds. The paradox arises from the gift-giving theory, which assumes feelings of indebtedness in the receiver of the gift. However, some researchers argue that sharing is neither a variation of gift-giving nor a reciprocal exchange. Taking this position, I explore the roots of the taboo in the Baka's ontology of hunting. The taboo likely originated from the hunter's indeterminate state between humans and spirits and the ambivalent character of spirits as bringers of both food and death. According to their ontology, the hunter's act of eating meat would result in determining whether he is a human or a spirit, thus causing undesirable consequences anyway. The hunter, therefore, abstains from eating the meat and remain in the indeterminate state. At the site of the elephant feast, the taboo creates a sharp contrast between the hunter with an empty stomach and others who have sated themselves with the meat. There, the hunter never sees himself as having given the meat to the others, and the others never see the meat as having been given to them by the hunter. He is excluded from the community of sharing, without being identified as the giver of the meat. This way, practicing the taboo realizes zero-to-all division, which is in contrast to the reciprocal one-to-one giving.

19.1 INTRODUCTION

In the Baka, a Central African hunter-gatherer group also known as "Pygmies", a strange taboo is observed: the man who delivers the first spear blow or gunshot to an elephant or a red river hog is forbidden from consuming any of its meat. His

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older relatives, except for his maternal uncles and grandparents, cannot consume it either. Should this taboo be broken, they believe, the hunter will never be able to kill another one again. The taboo about the red river hog can be lifted for men who have enough experience killing hogs, while it is less so for the elephant.

Sato (1993) first documented this taboo and argued that sharing meat under this taboo serves as a levelling mechanism for egalitarian hunter-gatherers, who live in an immediate-return system (Woodburn, 1982). The egalitarian hunter-gatherers achieve dual equality: economic equality through the thoroughly equal distribution of food, and social equality through the prevention of power and authority being bestowed on certain individuals. In this sense, they are egalitarians. However, a paradox arises when we adopt the theory of gifts (Mauss, 1923/1924), one of the most influential anthropological theories, to interpret the practice of food sharing among hunter-gatherers. When something is given, feelings of indebtedness arise in the receiver, and elevates the giver to a position of superiority. The receiver gives back something equivalent to offset the imbalance, or something more valuable to turn over the relationship. This way, gifts generate reciprocal exchanges. If this is the case for hunter-gatherers, they cannot achieve dual equality in a straightforward fashion. The meat undermines this dual equality. It is quite normal that considerable disparities exist between individuals in their ability to procure meat and, therefore, the meat tends to be transferred in fixed directions through consecutive sharing. According to the gift-giving theory, numerous individuals thus become indebted to a skilled hunter. Should this occur, social equality would become unsustainable.

As Sato (1993) argued, some rules, norms, or institutions of egalitarian hunter-gatherers have been interpreted as social apparatuses aimed at averting this paradox. One of the most sophisticated examples reported concerns the !Kung in Kalahari (Lee, 1979). Among the !Kung, a hunted animal belongs to the owner of the first arrow. The crafting of arrows is an easy task for them. They frequently lend arrows among one another, so that each man has arrows of others in his quiver. The point concerning the paradox is that, to avoid the risk of accusations when the distribution of the meat is not to everybody's liking, hunters are not reluctant to hunt with someone else's arrow and pass him the responsibility for distributing the meat (Lee, 1979). Consequently, when an animal is hunted, it is usual that not the man who killed the animal, but another individual is appointed as the owner of the meat. Even when one man kills several animals in succession, ownership is credited to multiple men. This way, the directions of meat transfer disperse, and the amounts of meat given and received among the members will remain balanced in the long term.

In the case of the Baka, an elephant yields such large quantities of meat that many people are involved in sharing. The opportunities to kill elephants are limited to skilled hunters and few for others. Therefore, even if ownership of the meat is ascribed to the weapon's owner, it is unrealistic to balance the amounts of meat given and received even in the long term. Sato (1993) argued that the taboo works to prevent the provocation of feelings of indebtedness among those who share meat.

However, this argument is insufficient on some grounds. When the meat is shared, according to Sato, (1) receivers of the meat, in theory, must feel indebted to the hunter. However, in practice, (2) they never feel thus. The reason for this is (3) the hunter who killed the elephant does not possess the right to eat its meat. Contrary to Sato's argument, Proposition (3) is neutral with regard to both (1) and (2) or may even support (1). A rule that forbids the hunter from consuming meat can serve to increase his authority like a generous chief, or a big man, who works hard and gives his harvest to others, thus maintaining his elevated status. Therefore, to maintain Proposition (2), it must be assumed that the Baka are *a priori* egalitarians. If so, however, why do they not employ a more egalitarian-seeming rule that allows the hunter to get a share of the meat equal to that of the others?

An alternative approach to treating the paradox is to presume that it does not exist at all. This position may seem too radical because many studies have assumed the gift-giving theory, or reciprocity, while analyzing sharing among hunter-gatherers. However, some researchers have argued that sharing is neither a form of gift-giving or exchange, nor reciprocity (Price, 1975; Bird-David, 1990; Woodburn, 1998; Hunt, 2000; Tanno, 2004; Belk, 2010; Widlok, 2017). While taking this position, it is no longer important to demonstrate how the taboo functions to neutralize the imbalance in meat transfers, but it is necessary to explain how the Baka experience the taboo and how they can practice sharing without feelings of indebtedness to the hunter.

In this paper, I first explore the roots of the taboo in the Baka's ontology of hunting, which is based on the relationships between humans, animals, and spirits, and explain why those who consume meat do not feel indebted to the hunter who killed the animal. Second, I examine the structure of the Baka's sharing practice and identify a prototype of sharing, that is, the zero-to-all division, which is in contrast to the reciprocal one-to-one giving.

19.2 ELEPHANT HUNTS OF THE BAKA

The fieldwork on which this paper is based was conducted in Z Village in southeast Cameroon between 2001 and 2003. The study area comprises a gently sloping hilly terrain covered by tropical rainforests at elevations between 400 and 600 m. Today, most Baka lead sedentary lifestyles, making their homes in settlements close to those of neighboring farmers. Despite the considerable regional variation, the Baka in Z Village continues to spend several months in the forest foraging for wild food (Yasuoka, 2006a, 2009, 2012, 2013). As of 2001, the population of the village stood at 144 Baka and 11 Bantu-speaking farmers. Since the 1970s, most farmers have relocated to newer villages along the main road that runs between the region's major towns. Until the logging road was laid in 2002, journeys to Z Village necessitated travelling tens of miles on foot. Immediately after the logging road was opened, many poachers and merchants trading in bushmeat began to arrive in Z Village (Yasuoka, 2006b). These years were an extraordinary period when the measures against elephant poaching were not well enforced. I was in one of the hottest spots of elephant hunting.

Although the spear is the traditional hunting weapon among the Baka, they seldom hunt elephants with spears anymore. As of 2002, out of around 30 adult men in Z Village, 6 had killed elephants. Whereas over 10 men had stabbed elephants with their spears, only 3 had succeeded in killing them. Experienced master-hunters are called *tuma* in the Baka language, as well as in other hunter-gatherers of the Congo Basin (Bahuchet, 1985; Ichikawa, this volume; Lewis, this volume). In most instances, hunts are carried out using guns, that is, rifles, provided by neighboring farmers, merchants, and so on. Although elders mentioned that they had also used a shotgun loaded with a spear in earlier times, this method was not found during the fieldwork. Along with the weapon, the gun owner provided three, or at most, ten bullets. It is the gun owners who decided whether they took only the tusks or both the meat and tusks. Even in the case of those demanding both, half the meat was left to the Baka.

An elephant hunt expedition is called *màka*. In the 25 elephant hunts carried out in Z Village in 2003, the number of people who participated in a hunt ranged from 1 to 22 people, with the average being 7 people, including a few young boys who did not carry spears. The *nganga* who locates the game using the fur of the African palm civet often participated in these hunts. Even in a large-scale hunting group, only a single individual is responsible for firing the gun, having been entrusted with it by its owner. The other men are usually armed with spears alone. Joiris (1996) reported that the hunter who had to kill the prey was appointed in a hunting ritual before the hunt. However, during my fieldwork, the non-Baka gun owner decided whom he would entrust the hunt to, and it was usually the *tuma*.

The elephant hunt begins with the hunters walking through the forest for several days in search of fresh traces of elephants. Larger groups are more readily able to find traces and track elephants. Searching and tracking are carried out in small groups of several individuals, while remaining aware of the other groups' movements. The primary purpose of this hunt does not prevent men from undertaking other activities on the way. Even while tracking their prey, they always scan trunks and branches in search of honey. As rations provided by the gun owner diminish rapidly when the hunting group is large, the members subsist on honey alone for a couple of days, at times.

The Baka can recognize whether elephant traces were left fresh that day or not. Once they chance upon traces that have been left on the given day, they begin tracking the elephant. The expeditions arrive at an area located 20–30 km, and sometimes 50 km away from the village. In the 25 cases recorded, the elephants were shot in 4.4 days on average after the departure, and the expeditions lasted 10.3 days on average before the hunters returned to the village. The hunters most often found elephants in wet grasslands, called *bayi* in Baka. Once they track down an elephant, the participants erect a camp some distance away and wait until dusk. Only the man who shoots the elephant, sometimes with a few others, approaches the target. The shooter aims at the animal's heart from the diagonal rear. He may also choose to aim for the head. Although a single shot can kill an elephant, he shoots a couple of bullets, if available, to avert the danger of a counterattack.

I witnessed the scene of a hunter returning to the camp where the others were waiting after he had killed an elephant, on two occasions. The people waiting at the camp continued to prepare the beds and food quietly, even when they heard the shots, as though voicing their expectations may jinx the hunt. If the hunter returns without killing the elephant, they continue doing their tasks with indifference. If the hunter is successful in killing the elephant, everyone is delighted with the expectation of eating the meat, except the hunter himself. On neither occasion does the man engage in boastful behavior, join in the elation of the others at the hunt's success, or receive words of praise or thanks. The scene shares a number of similarities with that described by Ichikawa (1982) in his work on the Mbuti of the Ituri Forest in the northeastern Congo Basin: "[…] Salambongo returned. He was carrying the spear on his shoulder, which indicated that the prey had been killed. The people, finally free of the tension of waiting, began to make merry, jumping up and down. I had thought that Salambongo would return to bask in the cheers and applause, exulting in his success. Contrary to my expectations, however, nothing in his demeanor suggested as much as a shred of this. When I waved my hand to greet him, he was embarrassed and lowered his gaze. If I had not known the meaning of the manner of holding the spear, or if I had not known what kind of person Salambongo was, I never would have noticed that he had hunted an elephant […]" (Ichikawa, 1982: p. 93, translated by the author).

The following morning, the camp relocates to nearby the hunted elephant. Each participant, except the hunter who killed the animal, builds a rack for smoking the meat and butchers the elephant. Each cuts a piece of the meat for himself. All of them take comparable amounts. At this time, a few of the participants may return to the village and speak in the voice of a forest spirit who makes the elephant's death known to the people. Those who come from the village meet others at the butchering camp, where the elephant meat feast begins. As the hunter who killed the elephant must not eat the meat, he does not join the feast. He goes off alone to fish or forage for honey. The others make no particular mention of him while enjoying their share of the meat. His older relatives, who are also forbidden from eating the meat, are not present at the camp.

Figure 19.1: The *jengì*.

19.3 ROOTS OF THE TABOO IN BAKA'S ONTOLOGY OF HUNTING

19.3.1 ELEPHANT HUNTS AND SPIRITS

As mentioned above, the Baka adheres to the taboo because a transgression causes the hunter to lose his ability of killing another animal again. The consequences of this taboo differ from those of other food restrictions among the Baka, which are generally because of anxiety that their infants or unborn children may suffer various illnesses. In the interviews I conducted with 85 adult men and women in Z Village, I found that they avoid eating 55 animal species out of the 63 that are normally considered edible for them, in certain circumstances. The remaining eight species that everyone consumes are Peters's duiker, blue duiker, water chevrotain, brush-tailed porcupine, giant pangolin, spot-nosed monkey, red river hog, and elephant. Like other hunter-gatherers in the Congo Basin, who have similar food restrictions (Bahuchet, 1985; Ichikawa, 1987; Takeuchi, 1994; Lewis, 2008), the Baka practice restrictions in varying degrees of seriousness based on the different situations and experiences of individuals. However, the taboo under consideration, which applies only to the elephant and the red river hog, is distinct from food restrictions of this nature: all the Baka strictly adhere to the taboo.

This taboo is likely rooted in the Baka's hunting tradition and related rituals. While the elephant is the largest animal that is hunted with a spear, the traditional hunting tool of the Baka, the hog is most frequently hunted with a spear. The Baka do not think a spear blow or a gunshot necessarily results in death. It often fails in reality. Failure is, they recognize, because of *gbɔ̀kɔ̀*, which means "bad luck" (Brisson, 2010). What brings good luck to the Baka then? Their rituals. The Baka usually carries out a hunting ritual as a form of the *ɓè*, communal singing-and-dancing gatherings. The *ɓè* is held to cure diseases, sometimes, and just for entertainment on other occasions. Above all, the *ɓè* has been organized as a hunting ritual associated with the *mɛ*, the forest spirits (Joiris, 1993, 1996, 1998). Tsuru (1998) recorded over 50 different *mɛ* in southeast Cameroon. A single Baka residential group possessed between zero and nine different kinds of *mɛ*, with an average of three (Tsuru, 1998). Several types of *mɛ* were widely spread over southeast Cameroon, while others were more recently created and limited to a small area. In Z Village, four kinds of *mɛ* were observed: the *jengì*, the *mòkondi*, the *ɓùmà*, and the *ʔèmbòàmbòà*, all of which are widely spread in southeast Camer-

	Number of elephants killed	Number of elephants shot but escaped	Success rate
January	0	0	38%
February	4	4	
March	1	4	
April	6	2	83%
May	2	0	
June	5	0	
July	5	3	
August	6	0	

Table 19.1: Results of elephant hunts in Z Village, January–August 2003.

oon. The *mòkondi* is the same spirit as *ʔàbàleè* or *kòse* recorded in other areas and is sometimes used to refer to spirits collectively instead of *mɛ* (Joiris, 1996, 1998).

The night before an elephant hunt begins, the Baka carries out the *ɓè* to ensure a successful hunt, which is organized by the ritual association of the concerned *mɛ*. The *mòkondi* (*ʔàbàleè* or *kòse*) dance is widely performed to attract and locate game animals, which is led by the *nganga* who locates the game (Joiris, 1996, 1998). During my fieldwork in 2003, at first, the *mòkondi* appeared and danced at the *ɓè* for elephant hunts. Between the end of February and the middle of March, all gunshots aiming at the six elephants failed. Then, a master-hunter, who is also the head of the *jengì* ritual association, invited the *jengì*, and sought to reverse their "bad luck" in the hunt. The *jengì* appeared in Z Village, where it remained until the beginning of September 2003 (Fig. 19.1). Although each gathering of *ɓè* of the *jengì* did not directly correspond with each hunting expedition, for the first three months of his stay, from mid-March to mid-June, the *ɓè* were held almost every night and occasionally early in the morning. At this time, boys and I were initiated into the *jengì* ritual association.

The *jengì* is considered the father of the other *mɛ* and the *mɛ* of elephants (Joiris, 1998; Tsuru, 1998). It is violent and aggressive toward women, in particular (Tsuru, 1998). During *jengì* dancing, the men form a wall to protect the singing women from the *jengì*. Although the Baka's ritual practice is generally fluid, flexible, malleable, and not always well organized (Joiris, 1996, 1998; Tsuru, 1998, 2001b; Fürniss and Joiris, 2011), the *ɓè* of the *jengì* in which I participated were much more tense and serious than those invoking other kinds of *mɛ*. Joiris (1996) mentioned that the *ɓè* of the *jengì* aims to contribute to the preservation of peace and harmony in the community. Besides, the *jengì* plays an important role in the hunt by walking alongside the elephant; the *jengì* not only protects the Baka from all perils of the forest, but also guides them to the game using visionary power (Joiris, 1996).

The presence of the *jengì* seemed to have had a large influence on their hunting performance. The elephant is the largest, strongest, and most dangerous animal in the forest. Therefore, approaching it is equivalent to approaching a danger that may result in death. Even while using a gun, a hunter must come within five meters of the target. It is likely that, by dancing with the *jengì* every night and perceiving its power in proximity, the hunters became sufficiently courageous to draw closer to the elephants and administer fatal shots with precision. As shown in Table 19.1, the difference in the success rates in the two periods is evident. In February and March, when hunting results were poor, only 38% of the elephant shots were killed (5 out of 13). After the arrival of the *jengì* at the end of March, however, the rate jumped to 83% (24 out of 29).

As soon as an elephant is killed, the *pɛ̀mbɛ̀*, also called *nyaɓolà* in other areas (Joiris, 1993, 1996), come to the site. The *pɛ̀mbɛ̀*, the *mɛ* of deceased master-hunters, does not make an appearance, but rather shout to make the elephant's death known to the people. The Baka tell the *jengì* and other kinds of *mɛ* to come to the site to eat the meat, but they do not show themselves as they do when they dance in the village. When I joined a group that left the village to the butchering sites, the voices of the *jengì* resonated through the forest during the trip. Although only the voices were present in the forest, women, who were not initiated into the *jengì* association, were afraid of it. Usually, while walking in the forest, women split into small groups and forage for various foods. On this occasion, however, all the women walked together. They seemed fearful of the *jengì*'s presence.

To the *mɛ* who come to the site, the Baka offer pieces of meat, which is called *lìkàɓò*, to thank them for their protection and assistance (Joiris, 1993, 1996). I did not directly observe this practice. Joris (1993, 1996) noted that the parts of the meat that are offered to different *mɛ* are predetermined; for example, the *jengì* takes cooked unseasoned ribs and heart pieces. However, no *lìkàɓò* is offered to *pɛ̀mbɛ̀* (*nyaɓolà*) because they do not eat the meat at all. This is suggestive because the taboo forbids the hunter's older relatives as well from eating the meat. Considering that *pɛ̀mbɛ̀* are deceased master-hunters, likely the forefathers of the hunter who killed the elephant, their abstaining from eating the meat is consistent with the description of the taboo.

19.3.2 THE TABOO AND THE SPIRIT

The Baka practice their taboo based on the relationships between humans, animals, and the *mɛ*. The hidden logic of the taboo seems to lie in these relationships, particularly between humans and the *mɛ*. According to Joiris (1993, 1996, 1998) and Tsuru (1998, 2001a), the *mɛ* are anthropomorphic. They live in the forest and appear as naked humans with bushy beards, have two genders, and age as human beings do. Their shyness induces them to wear costumes when they come to human settlements. They are often considered ancestral spirits. They possess the abilities that humans do not, but these are nothing like the omnipotence of the creator god. Occasionally, they appear in Baka's dreams and teach them ritual songs and medical plants. They approach humans who are alone in the forest and ask them to eat together, to make love, and to marry them, which often causes human death. A *mɛ* occasionally becomes a human, and in its place, a human becomes a *mɛ*. Tsuru (2001a) argued that the transformability into the *mɛ* lies at the root of the Baka's fear that if one is stranded alone in the forest and meets a *mɛ*, one will then become a *mɛ* and be unable to return to the human community. The Baka, therefore, find the *mɛ* eerie and ominous.

As mentioned above, the *mɛ* bestow luck on the Baka's hunt. However, it is not without the ambivalent characteristics of the *mɛ*. Tsuru (2001a: pp. 173–174) recorded a song-fable that encapsulated the ambivalence of the *mɛ*'s involvement in the elephant hunt:

1. There was a man who lived with his wife's family. After a visit to his parents, while walking in the forest to his in-law's camp, he encountered a *mɛ*.
2. The *mɛ* peeled off the man's skin and placed it on himself. The *mɛ* placed its skin with boils and wens on the man.
3. The two arrived together at the camp. The man's in-laws thought that the *mɛ* wearing the man's skin was the man himself.
4. The *mɛ* lay with the man's wife. The man instead lay with his wife's sister.
5. The following day, the *mɛ*, still in the man's skin, participated in the *màka*, a hunt for elephants and hogs, with the man's in-laws.
6. The man in the *mɛ*'s skin spoke to his wife's parents, and they removed the skin.
7. The man, in his usual appearance, carried out a *màka* and hunted an elephant and hogs.

8. The *mɛ* wearing the man's skin failed to kill an elephant and returned to the village.
9. The in-laws realized that a *mɛ* was wearing the man's skin. They captured it and beat it. The *mɛ* shed the man's skin.
10. His wife's sister died as a result of engaging in sexual contact with him in the *mɛ*'s skin.

I also collected the same song-fable in Z Village, with a small variation in sections 7–9.

7'. The *mɛ* wearing the man's skin killed an elephant and hogs and provided abundant meat for the man's in-laws.
8'. = 9.
9'. = 7.

This song-fable includes many points that are relevant to the taboo in question. First, a mutual transformation occurred between the *mɛ* and man. There is a difference in hunting results between the variations: the *mɛ* failed in the hunt in section 8, while the *mɛ* provided abundant food to the Baka in section 7'. However, the common element between both stories was the man who had successfully hunted the elephant, and who had spent the previous night as a *mɛ*, having donned its skin. When an elephant and hogs are hunted in both variations (sections 7 and 7'), the man and the *mɛ* look identical. The others may not be able to discern whether the figure that actually killed the elephants and hogs is the man himself or the *mɛ* wearing the man's skin.

Second, the *mɛ* was regarded as a cause of death. The woman died from sexual contact with the man wearing the *mɛ*'s skin. This motif is not limited to this song-fable alone. In those collected by Tsuru (2001a), the *mɛ* frequently has sexual relationships with, proposes marriage to, and shares meals with the Baka, who eventually die as a result. These consequences probably reflect the Baka's belief that the *mɛ* are humans who have died and gone to live in the forest and, therefore, to engage in a relationship too closely with the *mɛ* is to approach death. Joiris (1993) recorded the discourse of a Baka woman that men do not have sexual intercourse before a hunt. This is because, according to the woman, the men are ready for the struggle with elephants under the guidance of the *mɛ*. Her discourse seems consistent with the consequence referred to in the above song-fable.

This song-fable appears to encapsulate the Baka's anxiety that a skilled hunter who provides abundant meat may not be a pure human being and may cause death as well. This interpretation is also supported by Köhler's (2001) report on the Baka in northwest Congo-Brazzaville that a master-hunter was thought to have the privileged abilities of accessing the spirit world and shapeshifting. Therefore, on occasion, such as a series of unexpected deaths of people close to him, he was suspected of having "eaten" them to enhance his ability.

Here are the keys to untangling the hidden logic of the taboo: the hunter's indeterminate state between a human and the *mɛ*, and the *mɛ*'s ambivalent character as bringers of both food and death. Let us conduct a thought experiment: what will happen when the man who has killed an elephant shares the meat with others? If any of them die or become seriously ill after consuming the meat together, the hunter will reveal himself to be a *mɛ*, or at least to be a dangerous person who "eats" others. Were this to occur, he could no longer live with others. On the other hand, if nothing noteworthy happens when the hunter consumes the meat, he will prove himself to be an ordinary human without the privileged abilities anymore. He decided in contradiction to the power of the *mɛ*. Consequently, he will fall into "bad luck" forever and never again be able to kill another. To avert both undesirable consequences, the hunter must abstain from eating the meat and remain in the indeterminate state between human and the *mɛ*. Everyone I interviewed explicitly referred to only one side of the logic behind the taboo: "if the hunter eats the meat, he will never be able to kill another animal again". The other side of the logic is not what the Baka explained themselves, but what I deciphered based on the abovementioned ethnographic descriptions.

The hunter's indeterminate state and *mɛ*'s ambivalent character are not only indicated in song-fables but are also embodied in every Baka through the contrast at the elephant feast generated by the taboo. At the feast, there is a sharp contrast between the hunter with an empty stomach and others who have sated themselves with meat. This way, practicing the taboo reproduces and reinforces the relationships between humans, animals, and the *mɛ*, which lies at the core of the Baka's ontology of hunting. We should also note that, although only small numbers of the Baka have experienced killing an elephant, many men have killed red river hogs and have been temporarily excluded from the community of sharing. Thus, not only the master-hunters of the elephant, but also many others have commonly experienced being on both sides. Their comprehensive involvement in practicing the taboo ensures the continuity of the ontology underlying the taboo.

19.4 SHARING AS ZERO-TO-ALL DIVISION

19.4.1 SHARING IS NOT RECIPROCAL ONE-TO-ONE GIVING

Previous studies have pointed out the regional diversity in the Baka's ritual practices and the neighboring farmers' influences on them (Joiris, 1993, 1996, 1998, 2003; Tsuru, 1998, 2001a, b; Köhler, 2001; Fürniss and Joiris, 2011). However, it is confirmed that the Baka practice the taboo we focus on in this study, not only in Cameroon but also in northwest Congo-Brazzaville (Sato, 1993; Köhler, 2001). The *jengì* refer to the most widely distributed spirits among the Baka (Tsuru, 1998, 2001b) and are supposed to be identical to the spirits called *Ejɛngi* among other hunter-gatherers in the western Congo Basin (Lewis, 2015, 2019, this volume). Therefore, we can assume that the core of the taboo and related hunting rituals is common among the Baka.

Distributing elephant meat among the Baka takes place over several phases. After a hunter kills an elephant, others who participated in the hunt butcher the animal. There are no particular rules governing the butchering phase. Each gets any portion of meat he cuts off, and all participants divide the elephant's meat almost evenly, except for the hunter who killed the animal. This is the first phase. Those who did not participate in the hunt arrive at the butchering camp, and the original participants transfer pieces of meat to them. They consume some of the meat and take the rest to the village, where the meat is transferred to others. This is the second phase. Finally, cooked meals are given to the neighbors or are eaten together, which is the third phase. The distinction between the first phase of "dividing the meat" and the second phase of "giving the meat" is important. The former is practiced based on a zero-to-all interaction (Fig. 19.2), whereas the latter appears to be performed based on a one-to-one interaction.

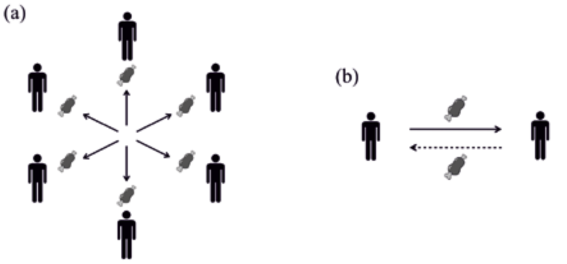

Figure 19.2: Different models of food transfer: a, sharing based on a zero-to-all division; and b, reciprocal exchanges based on one-to-one interactions. A dotted arrow indicates an expected counter-gift

In the first phase, the people divide the meat without identifying anyone as the giver. It may seem unrealistic, but it is possible because the hunter is excluded from the community of sharing without being identified as the giver. A similar practice of sharing among peoples of the North American Arctic and Subarctic has been documented (Tanner, 1979, this volume; Nadasdy, 2007; Omura, 2013). Omura (2013) argued that sharing food requires the presence of an outsider who does not take a share of the meat; for the Inuit, it is the hunted wild animal itself. According to

Figure 19.3: Dividing honey among everyone on the spot.

the Inuit's ontology of hunting, what hunters have to do to hunt wild animals is to tempt them to give their bodies to humans. Animals that succumb to the temptation offer themselves to the Inuit, thus issuing an order for their meat to be shared and consumed. If this does not happen, wild animals will never be reborn, and their population will not be replenished. The Inuit share the meat and the techniques used to tempt the wild animals as well, and forge social ties among themselves. Whereas the Inuit identifies the hunted animal as the giver that orders them to share the meat, the Baka does not say that either the animal or the hunter behaves that way. Although the Baka does not say that the *mɛ* order them to share the meat among themselves, they offer portions of meat to the *mɛ*. We may say that *mɛ* plays the role of an outsider in the community of sharing that Omura indicated. However, the most important common point in both cases is that the hunter who killed the animal is not identified as the giver of the meat and, thus, no giver exists in the community of sharing. Each has their ontological framework wherein the hunter never perceives himself as having given the meat to the others, and the others never perceive the meat as having been given to them by the hunter. Thus, zero-to-all division is achieved.

Food sharing among hunter-gatherers is often explained as a variant of gift-giving or reciprocal exchanges, which are typical of one-to-one interactions that generate and are generated by the feelings of indebtedness (Widlok, 2017). In contrast, I argue that the Baka's practice of meat sharing is not one of the variants of one-to-one giving, but a demonstrably different interaction, namely the zero-to-all division. Unlike the reciprocal one-to-one giving, no functions of the giver exist in the community of sharing created by the zero-to-all division.

19.4.2 WHY DOES THE "OWNER" EXIST?

The Baka likely practice the zero-to-all division in sharing other foods as well, in which the *mɛ* is not directly involved. As mentioned above, the taboo about the red river hog can be lifted for men who have enough experience killing hogs. This means that, unlike the elephant, the hog can be killed by mature men alone. The taboo is lifted by eating hog meat with a special remedy, generally after getting a child. However, even after being freed from the taboo, the hunter who killed a hog does not behave as the giver of the meat.

Generally, the hunter passes the animal to someone else, who butchers it and divides the meat for everyone, while the hunter behaves merely as one of those who receives a share of the meat. In sharing honey, the individual who found the honey is identified as its “owner”. The “owner” can decide to harvest it and, after the harvest, divide the honey among everyone on the spot (Fig. 19.3). The “owner” is allotted a portion of the honey equal to those received by the others. In each case, although the hunter or the “owner” joins the community of sharing, the people do not recognize him as the “giver”, but merely as an agent of distribution.

While addressing the function of the “owner” among hunter-gatherers, Kitanishi (1998) reported an interesting case involving the Aka in north Congo-Brazzaville. A Bantu farmer asked several Aka people to carry a canoe to the river. He filled a pail with cassava fufu for the workers. Normally, a Bantu farmer himself distributes the food to all workers or nominates someone else as a distributor. However, in the case observed, the farmer simply put the pail down and left without saying anything. Then, each of the Aka workers rushed up to the food and took all that they could each hold in their hands. Workers who were absent at the time got nothing.

This exceptional case shows what happens if there is no “owner”, that is, no distributor, in the zero-to-all division. When the food source is as large as an elephant, the uncontrolled butchering of the meat by everyone can still result in everyone being satisfied. However, if the food source is not large enough, uncontrolled division likely results in an imbalanced distribution of the food, which may trigger a conflict. In such cases, the “owner”, who divides the food himself or nominates a distributor, is necessary. Generally, there is a person who is granted legitimacy as the “owner” by the community of sharing—not necessarily the man who hunted the animal. For example, in the case of !Kung, the man who crafted the arrow that killed an animal is appointed as the “owner” (Lee, 1979). The Aka (Bahuchet, 1990; Kitanishi, 1998) and the Mbuti (Ichikawa, 1983, 2005) follow the same approach toward defining the ownership of prey.

19.4.3 ONE-TO-ONE OR EXTENDED ZERO-TO-ALL?

The Aka has a taboo that is similar to the one we have examined thus far (Bahuchet, 1990; Takeuchi, 1994; Kitanishi, 1998). Although there are some variations by regions and hunting methods, in principle, the owner of the weapon that immobilized the animal becomes the “acquirer”, who is in charge of sharing. If the hunter used a borrowed weapon, its absent owner is the “acquirer”. If the “acquirer” of the animal is an adolescent, he and adult women are forbidden from eating the meat. There is a difference between the Aka and the Baka. Among the Aka, weapon ownership defines who cannot eat the meat, whereas, among the Baka, the hunter cannot eat the meat, regardless of the ownership of the weapon. However, in both groups, someone is excluded from the community of sharing.

Among the Aka and the Mbuti, roles in hunting predetermine who gets to take what parts of the meat (Ichikawa, 1983, 2005; Bahuchet, 1990; Kitanishi, 1998). For example, according to Kitanishi (1998), when Aka hunted a red river hog with spears, the owner of the spear that dealt the second blow takes its dorsal midriff, and the owner of the spear that dealt the third blow takes the head. If the first blow is dealt with by a borrowed spear, the borrower (hunter) takes the rump. The owner of the spear of the first blow obtains all the remaining parts. This first phase of sharing results in only a few people obtaining the meat. In contrast, when the Baka hunt a hog, they divide the meat among everyone on the spot (the hunter who killed the hog takes no share if he is young). However, the final results of both are comparable because Aka carries out the second phase of sharing so thoroughly that the meat does not concentrate in the hands of specific persons or families (Kitanishi, 1998, 2000). The difference is that the first phase of sharing plays a relatively minor role among the Aka.

We should not overemphasize this difference by inventing an insurmountable gap between "dividing the meat" and "giving the meat" which occur successively in the Baka's meat sharing practice, though I have pointed out the distinction between zero-to-all and one-to-one interactions above. The Baka practice "dividing the meat" in the first phase, and "giving the meat" in the second. In the latter phase, those who have the meat give pieces to others who do not participate in the hunt. If feelings of indebtedness were to arise among those who received the meat, they would have practiced "giving the meat" as reciprocal one-to-one giving, wherein the giver and the receiver contrast sharply. However, this does not seem to be the case. Re-transferring pieces of meat are likely practiced as an extended sequence of "dividing the meat". When the Baka "give" someone else a piece of meat, or cooked meals, the "givers" usually have children carry the food to the receivers. While passing and receiving food, there are few conversations, and no remarks of thanks are mentioned to the "giver". They seem very careful about avoiding manifesting the asymmetry between the actors that would be emphasized if it were to be one-to-one giving. Interestingly, they do not appear to minimize occasions of food transfer. Instead, they transfer food far more frequently than needed to level food distribution among them, as documented for the Mbuti (Ichikawa, 1981) and the Aka (Kitanishi, 1998, 2000).

These features, that is, the inexpressive attitude and excessive frequency, which contrast sharply with those of ostentatious gift-giving practiced in non-egalitarian societies, are understandable from the perspective that re-transferring food is a repetition of the zero-to-all division out to the extended community of sharing. Multiple models of food transfer coexist in a society, and an appropriate model varies based on the context and relationships among the actors. According to my observations, the Baka hunters transfer the meat to other Baka as though extending the community of sharing (i.e., a repetition of the zero-to-all division). They give the meat to a Bantu farmer with the aim of cultivating a relationship with a particular person (i.e., the reciprocal one-to-one giving). They sell the meat to a merchant as a commodity (i.e., another model of one-to-one interactions). In situations where different models of food transfers coexist, the potential problem for the actors is that the intent of each is different or misunderstood. Specifically, even if the "giver" intends to pass on a piece of meat as a repetition of the zero-to-all division, the meat necessarily moves from one person to another, which appears like a one-to-one giving. Then, the "giver" supposes that the receiver may suspect that the "giver" seeks to attain superiority over the receiver. Being anxious about the arousal of such an inferiority complex in the receiver, the "giver" passes a piece of meat in a manner as indifferent and as un-expressively as possible. Thus, they tacitly emphasize that they transfer the food not as a part of one-to-one giving, but as a repetition of zero-to-all division.

Another point that induces excessive frequency in food transfer is the absence of the perspective of centralized redistribution, which is more efficient, but often coercive. In other words, each transfer of food occurs between independent individuals, and no one controls the overall allocation of harvests among the members. As Ichikawa (1981) described, for the Mbuti, it is quite often the case that one who gives a piece of honey to another is given another piece of honey from someone else on the same day. What is critical for initiating zero-to-all division (and its repetitions) is the visualized imbalance of food allocation between individuals on the spot. When someone is with food and seen by someone else without food, he or she can do nothing but divide it up. However, egalitarians are not necessarily "ethical". I sometimes observed that the Baka youngsters hid packages of honey outside the campsite to eat at night. Even if they notice it, others do not condemn them for doing so, at least publicly. Although concealing honey is sometimes possible, it is not realistic to conceal meat or other types of food that should be cooked. Against this background, repetitive food transfers, and bubbles of sharing, are practiced among individuals, thus extending the community of sharing.

19.4.4 FROM ZERO-TO-ALL TO ONE-TO-ALL?

The Baka divides elephant meat without the consciousness of giving or receiving the meat. Their ontology of hunting enables this by creating a temporary community of sharing and placing the hunter who killed the elephant outside it. Omura (2013) pointed out that sharing food is realized under the "order" of someone outside the community of sharing. As long as it is granted legitimacy, anything can issue the "order"; for example, the hunted animal, as is the case for the Inuit, a counterpart group of reciprocal exchanges, or a transcendent being, such as the king, the god, and the state. The status of the hunter who killed an elephant should be examined in this light as well. He is outside the community of sharing, but unlike the *mɛ* who receive the *lìkàɓò* offering, he is not a counterpart of reciprocal exchanges. Offering meat to the hunter means that the people identify the hunter as a *mɛ*, which makes it too dangerous to live together with him. Of course, he is not normal enough to share the meat. Therefore, he remains in an indeterminate state between humans and the *mɛ* and never consumes the meat.

Then, can he be a transcendent being? If so, it would be difficult for the Baka to remain egalitarian. We should recall that many Baka experience the indeterminate state. Almost all the Baka men have killed red river hogs and have consequently been temporarily excluded from the community of sharing. The hunter does not play any role in the process of sharing. This is likely why he appears to lose sociability while others consume meat. However, the hunter's exclusion from the community of sharing lasts only for a short while until the meat is all consumed. We should say, rather, practicing the zero-to-all division creates a temporary community of sharing. The hunter who kills the animal and is excluded for this time will join the newly created community next time, unless he is the hunter again. Being indeterminate is ordinary for all of them. Furthermore, killing many hogs sets men free from the taboo. In other words, gaining hunting experience does not mean that the hunters are becoming transcendent, but rather becoming incorporated into the community of sharing.

Non-linguistic transmission between generations is important while examining the stability of egalitarian societies (Lewis, 2008). In societies that depend heavily on linguistic transmission, individuals with authority who evaluate the correctness of cultural practices may emerge, which contradicts the egalitarian approach (Brunton, 1989). In the context of the taboo we focus on, the Baka only refer to the final consequences of the transgression, and its logic remains tacit even for the Baka themselves. Involvement in various practices concerning the taboo, such as listening to song-fables, being initiated into ritual associations, dancing and singing with various *mɛ*, seeing his fathers and older brothers being forbidden from eating the meat, hunting red river hogs and elephants, and being excluded from meat sharing as a hunter or as the hunter's older relative, stimulate every Baka to embody the ontology behind the taboo. If master-hunters begin to employ explicit terms to explain the logic of the taboo, the zero-to-all division may transition into the one-to-all redistribution, thus situating the hunters in a place transcendent from the community.

19.5 CONCLUSIONS

Among the Baka hunter-gatherers in the Congo Basin Rainforest, elephant meat sharing is closely related to a taboo that forbids the hunter who killed the elephant from eating the meat. The analysis revealed that the taboo originates from the hunter's indeterminate state between humans and spirits and the spirit's ambivalent character as bringers of both food and death. According to their ontology, the hunter's eating of meat would result in determining whether he is a human or a spirit, thus causing undesirable consequences anyway. Therefore, the hunter must abstain from eating the meat and remain indeterminate. At the site of the elephant feast, the taboo creates a sharp contrast between the hunter with an empty stomach and others who have sated themselves with meat. There, the hunter never sees himself as having given the meat to others, and the others never see the meat as having been given to them by the hunter. He is excluded from the community of sharing without being identified as the giver of the meat. This way, practicing the taboo realizes zero-to-all division, where no giver of the meat exists. Thus, excluding the hunter, practicing zero-to-all division creates a temporary community of sharing, and its repetitions extend to the entire community involving many people.

Food sharing among hunter-gatherers is often explained as a variant of gift-giving (Widlok, 2017). Zero-to-all division is an alternative prototype of sharing, which is distinct from the reciprocal one-to-one giving that generates feelings of indebtedness toward the giver. Comparable arguments have been made for other African hunter-gatherers (Woodburn, 1998; Tanno, 2004) and broader societies (Blurton Jones, 1987; Bird-David, 1990, 1992, 2005; Peterson, 1993, 2013; Hunt, 2000, 2012; Kishigami, 2004; Widlok, 2004, 2017; Belk, 2010). However, no studies have explicitly identified the zero-to-all division as a protype of the hunter-gatherer's practice of sharing. Besides sociocultural anthropological studies, behavioral ecological models of food sharing, such as kin selection-based nepotism, reciprocal altruism, tolerated scrounging, and costly signaling (Gurven, 2004; Kaplan and Gurven, 2005), generally assume that the receivers recognize the producer of the food as the owner, and the owner of the food as the giver. However, the alternative model I proposed here indicates that a social institution that separates these concepts, or even erases the giver, is essential for a human way of sharing.

Food sharing is considered one of the fundamental aspects of human sociality (Jaeggi and Gurven, 2013), and egalitarian hunter-gatherers practice food sharing on a daily basis (Widlok, 2017). However, the fact that many present or recent hunter-gatherers are egalitarians does not mean that most archaic hunter-gatherers were the same. Given that some non-human primates practice one-to-one food transfer (Jaeggi and Gurven, 2013), it is plausible that archaic hunter-gatherers also practiced one-to-one food transfer and an unsophisticated mixture of zero-to-all and one-to-one interactions as well. Gradually, the zero-to-all division became sophisticated and dominant in some groups, and the reciprocal one-to-one giving became dominant in others.

Then, when and why was each group compelled to choose one model of food transfer as a dominant one? A possible hypothesis for future study is that the expansion of big-game hunting induced it, as Barkai (2019) suggested. Large mammals provided archaic hunter-gatherers with a quantity of meat and oil that filled many people's bellies, which was potentially enormous wealth (Agam and Barkai, 2018). As the disordered distribution of wealth began to confuse economic and social relations, each group had to establish a manner of regulating relationships between the hunter who killed an animal and others who got shares of meat. Egalitarian hunter-gatherers likely emerged from groups that chose the zero-to-all division. They have persistently practiced it and resisted the transition to the one-to-one giving or the one-to-all redistribution. Those who chose or shifted to other models went different ways and established hierarchical societies. This does not mean that egalitarian hunter-gatherers have practiced only a single economic model. They have likely developed a dual economy in which other models are incorporated, especially for circulating non-local products (Lewis, 2019). However, those who developed a consistent ontology with zero-to-all division and succeeded in preventing other models from being predominant in daily life have remained egalitarian.

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In recent decades, a significant number of Pleistocene (ca. 2.6 million years–10,000 years ago) open-air and cave sites yielding elephant or mammoth bones in direct association with hominin remains and/or lithic artifacts have been discovered in Eurasia, Africa and America. Many of them show strong evidence of acquisition and processing of proboscidean carcasses by early humans, leading scientists to interpret them as ''elephant butchering sites''. Indeed, proboscidean exploitation by early *Homo* has been proposed to have been critical for Palaeolithic human lifeways, influencing not only their subsistence, but also other aspects of early human evolution and adaptations. The nature and degree of interactions between humans and elephants comprises an important field in palaeoanthropological studies since decades, but many questions remain still unanswered or partially explored.

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