

Bird Species Knowledge:
Assessing Trends, Influencing Factors, and Its Role in
Environmental Attitudes

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Zusammenfassung

Angesichts des rasanten Biodiversitätsverlusts ist es essenziell, das Bewusstsein für Artenvielfalt und deren Schutz in der Bevölkerung zu stärken. Artenkenntnis spielt dabei eine zentrale Rolle, da sie nicht nur das Verständnis für Biodiversität und Ökosystemfunktionen fördert, sondern auch die Akzeptanz und Umsetzung von Naturschutzmaßnahmen unterstützt. Vögel eignen sich besonders für die Untersuchung der Artenkenntnis, da eine gute Vogelartenkenntnis oft mit allgemeiner Artenkenntnis einhergeht. Zudem sind Vögel im Alltag vieler Menschen präsent, da sie meist tagaktiv und relativ gut sichtbar sind, und auch urbane Lebensräume besiedeln.

Diese Dissertation untersucht die Vogelartenkenntnis von Schüler*innen und Erwachsenen in zwei groß angelegten Studien. Da frühere Studien die Auswahl der untersuchten Arten meist nicht hinreichend begründeten, wurde in einer ersten Studie ein systematischer Auswahlprozess entwickelt. Hierfür wurden avifaunistische Datenbanken analysiert und eine Vorauswahl erstellt, die verschiedene Ordnungen, Häufigkeit und gesellschaftliche Relevanz der Arten berücksichtigt. Anschließend wurde die Vorauswahl durch zwei Expert*innen-Evaluationen verfeinert. Die resultierende Liste von 50 Vogelarten bildet die Grundlage für die zwei weiteren Erhebungen und erleichtert künftige Vergleichsstudien. Die angewandte Methodik kann auch auf andere biogeografische Regionen oder Taxa übertragen werden. An der Studie zur Vogelartenkenntnis bei Erwachsenen nahmen 3438 Personen aus ganz Deutschland teil. Die Teilnehmenden erkannten knapp die Hälfte der 50 abgefragten Arten zumindest auf Ordnungsebene. Es wurde gezeigt, dass Interesse an Vögeln und die Teilnahme an tierbezogenen Aktivitäten die Vogelartenkenntnis fördern, welche sich wiederum positiv auf umweltbewusste Einstellungen auswirkt. Zur Erhebung der Vogelartenkenntnis von Schüler*innen wurden 1752 Kinder und Jugendliche aus verschiedenen Schularten in Baden-Württemberg befragt. Sie erkannten im Mittel 33,5% der 30 abgefragten Arten zumindest auf Ordnungsebene. Auch hier wirkten sich Interesse an Vögeln und tierbezogene Aktivitäten positiv auf die Vogelartenkenntnis aus. Zudem spielten demografische Faktoren wie Alter, Schulart, Wohnortnähe zu Grünflächen und Gartenaktivitäten eine Rolle. Neben der Erhebung des aktuellen Standes der Vogelartenkenntnis bot die Schulstudie erstmals die Möglichkeit, valide zu untersuchen, ob diese im Vergleich zu vor knapp 20 Jahren tatsächlich abgenommen hat – eine bislang nicht empirisch belegte Annahme in Naturschutzkreisen. Im Schuljahr 2022/2023 lag die Artenkenntnis signifikant niedriger als 2005, besonders am Gymnasium und bei der Benennung der Arten auf Artebene.

Der Rückgang in Kombination mit der Bedeutung der Vogelartenkenntnis für umweltbewusste Einstellungen unterstreicht den Handlungsbedarf. Um diesen Rückgang zu stoppen, sollten Maßnahmen wie die Förderung von Interesse an Vögeln und die Einbindung tierbezogener Aktivitäten gezielt gestärkt werden. Dies kann der mit dem Kenntnisverlust einhergehenden *shifting baseline* (Verschiebung der Grundlinie) entgegenwirken und zu einer Bildung für nachhaltige Entwicklung beitragen.

Summary

Given the rapid loss of biodiversity, it is essential to increase public awareness of biodiversity and its conservation. Species knowledge plays a crucial role in this process, as it not only enhances the understanding of biodiversity and ecosystem functions, but also supports the acceptance and realisation of conservation efforts. Birds are particularly well suited for studying species knowledge, as bird species knowledge is often associated with general species knowledge. Moreover, birds are highly present in people's everyday lives, as they are mostly diurnal, relatively easy to observe, and commonly found in urban environments.

This dissertation examines bird species knowledge among school students and adults in two large-scale studies. As previous research has often lacked a well-founded methodology for species selection, a systematic selection process was developed in an initial study. This process involved analysing ornithological databases to make a pre-selection of species, taking into account taxonomic orders, species abundance and societal relevance. The list was then refined by two rounds of expert evaluation. The final selection of 50 bird species serves as the basis for the subsequent studies and allows for future comparative research. The methodology applied here can also be adapted to other biogeographical regions or taxa. The study on bird species knowledge among adults included 3,438 participants from across Germany. On average, participants were able to identify almost half of the 50 species at least at the taxonomic order level. The results show that interest in birds and participation in animal-related activities enhance bird species knowledge, which in turn positively influences pro-environmental attitudes. To assess bird species knowledge among school students, 1,752 children and adolescents from different types of schools in the federal state of Baden-Württemberg were surveyed. On average, they correctly identified 33.5% of the 30 species presented at least at the order level. Again, interest in birds and participation in animal-related activities had a positive effect on bird species knowledge. Demographic factors such as age, school type, distance from home to the nearest green space, and time spent in the garden also played a role. Beyond assessing the current level of bird species knowledge, the school survey provided the first opportunity to empirically test whether species knowledge has actually declined over the past almost 20 years – an assumption often made in conservation circles but not yet empirically validated. The results show that in the 2022/2023 school year, bird species knowledge was significantly lower than in 2005, particularly for students at the highest stratification level (Gymnasium) and when naming species at the taxonomic species level.

This decline, in combination with the importance of bird species knowledge in fostering pro-environmental attitudes, calls for urgent action. If this decline is to be halted, measures such as promoting interest in birds and integrating animal-related activities into education should be strengthened. This can counteract the *shifting baseline* associated with the knowledge loss and contribute to Education for Sustainable Development.

List of Publications

- Härtel, T., Vanhöfen, J., & Randler, C. (2023). Selection of indicator bird species as a baseline for knowledge assessment in biodiversity survey studies. *Animals*, 13(13), 2230. <https://doi.org/10.3390/ani13132230>
- Härtel, T., Vanhöfen, J., Großmann, N., & Randler, C. (2024). Unlocking biodiversity awareness: Influential factors on bird species knowledge and the links with environmental attitudes and connectedness to nature. *International Journal of Science Education, Part B*, 1-16. <https://doi.org/10.1080/21548455.2024.2381840>
- Härtel, T., Vanhöfen, J., Rosenberger, A., Heil, F., Ginter, M., & Randler, C. (2024). Assessing determinants and trends in bird species identification skills among students: A comparative analysis with early 2000s data. *International Journal of Science Education*, 1-25. <https://doi.org/10.1080/09500693.2024.2407561>

In Table 1, please find the contribution to publications according to § 5 Abs. 2 No. 8 of the PhD regulations of the Faculty of Science (Universität Tübingen, 2015).

Table 1: Overview contributions to publications by Talia Härtel.

Nr.	Accepted publication (yes/no)	List of authors	Position of candidate in list of authors	Scientific ideas by the candidate (%)	Data generation by the candidate (%)	Analysis and Interpretation by the candidate (%)	Paper writing done by the candidate (%)
1	yes	TH, JV, CR	1	25	60	60	80
2	yes	TH, JV, NG, CR	1	70	100	95	90
3	yes	TH, JV, AR, FH, MG, CR	1	70	70	95	90

Notes: TH = Talia Härtel, JV = Janina Vanhöfen, CR = Christoph Randler, NG = Nadine Großmann, AR = Alexander Rosenberger, FH = Felicitas Heil, MG = Marc Ginter.

Note: This thesis includes previously published work (all CC-BY licensed). Spelling errors identified after publication have been corrected without altering the content. Figures and tables have been reformatted for stylistic consistency, without changing their values or the type of graphs.

List of Abbreviations

- 2-MEV** Two Major Environmental Values.
- ADEBAR** Atlas Deutscher Brutvogelarten.
- API** Application Programming Interface.
- B.Sc.** Bachelor of Science.
- CBD** Convention on Biological Diversity.
- CFA** Confirmatory Factor Analysis.
- CFI** Comparative Fit Index.
- CR** Construct Reliability.
- CS** Citizen Science.
- EFA** Exploratory Factor Analysis.
- ESD** Education for Sustainable Development.
- FIML** Full Information Maximum Likelihood.
- GFI** Goodness of Fit Index.
- GLM** General Linear Model.
- GPCM** Generalised Partial Credit Model.
- IRT** Item Response Theory.
- M.Ed.** Master of Education.
- M.Sc.** Master of Science.
- MLR** Robust Maximum Likelihood Estimator.
- NABU** Naturschutzbund.
- NGO** Nature Conservation Organisation.
- PCA** Principal Component Analysis.
- RMSEA** Root Mean Square Error of Approximation.
- RSPB** Royal Society for the Protection of Birds.
- SDG** Sustainable Development Goal.
- SEM** Structural Equation Model.
- SRMR** Standardised Root Mean Squared Residual.
- TLI** Tucker-Lewis Index.
- UK** United Kingdom.
- UN** United Nations.
- US** United States.
- VIF** Variance Inflation Factor.

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1 Introduction

1.0 Biodiversity Loss

Biodiversity ‘means the variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems’ (UN, 1992).

This biodiversity is of great importance for ecosystem functioning and services (Cardinale et al., 2012). Different species fulfil different ecological roles and thrive under various conditions, helping to buffer the effects of disturbances such as natural disasters, disease outbreaks, and climate change (Dussault, 2019). Biodiversity underpins essential processes, including primary production, nutrient cycling, and decomposition (Cardinale et al., 2012). Moreover, it offers a range of ecosystem services that humans depend on, including provisioning, regulating, supporting, and cultural services (Fu et al., 2013; Reid et al., 2005).

Yet biodiversity is undergoing its fastest decline in human history (IPBES, 2019). Biodiversity loss is challenging to quantify due to different study methods and limited data on many species and regions (Isbell et al., 2023). However, experts agree that around 30% of species have become globally threatened or extinct since the year 1500 (Isbell et al., 2023). The rate of biodiversity loss varies significantly across Earth’s regions with particularly high losses in the tropics and freshwater ecosystems (IPBES, 2019). In the case of vertebrate species, the 2024 Living Planet Report estimates a 73% decline in populations globally between 1970 and 2020 (WWF, 2024). In Europe and Central Asia, this decline is comparatively lower, at 35%. Nevertheless, present extinction rates are estimated to be at least 1,000 times higher compared to natural background levels, signalling an ongoing sixth mass extinction, driven primarily by one species – humans (Cowie et al., 2022; De Vos et al., 2015; Pimm et al., 2014). Many species vanish even before being documented – a phenomenon known as *silent extinction* (Pimm et al., 2014) – occurring when species become extinct without being formally identified or studied, often in remote or understudied regions. This loss in biodiversity can trigger a cascade of declines in ecosystems, as the disappearance of one species can destabilise food webs and threaten overall ecosystem resilience (Gilljam et al., 2015).

Biodiversity loss undermines *biosphere integrity*, a key planetary boundary essential for the Earth’s stability. This threshold, rooted in genetic diversity and ecosystem functions, has already been crossed, signalling that biodiversity decline pushes humanity toward further environmental destabilisation. Biodiversity, therefore, should not be viewed in isolation but as part of a web of interrelated global changes that amplify each other’s impacts on Earth’s systems (Richardson et al., 2023).

Biodiversity is also directly linked to human well-being (Marselle et al., 2019). Recent studies demonstrate a strong link between biodiversity and both physical health (e.g., Aerts et al., 2018; Romanelli et al., 2015) and mental health (e.g., Gascon et al., 2015; Marselle et al., 2019). Through its threat to essential resources and quality of life, biodiversity loss impacts humanity as a whole (Díaz et al., 2018). Halting this loss has thus become ‘a defining challenge of our time’ (UN, 2021).

The global political recognition of biodiversity’s importance began with the 1992 Earth Summit in Rio de Janeiro, where the Convention on Biological Diversity (CBD) was established, marking a milestone in biodiversity protection (UN, 1992). The CBD set out ambitious goals to conserve biological diversity, promote ‘sustainable use of its components’, and ensure ‘the fair and equitable sharing of the benefits’ derived from genetic resources (UN, 1992). In 2002, the Convention agreed to significantly reduce the rate of biodiversity loss by 2010 (CBD, 2002). This target was not met. Hence, the Aichi Biodiversity Targets were adopted in 2010 to be achieved by 2020 (CBD, 2011). However, none of these targets were met by the 2020 deadline either (H. Xu et al., 2021). In 2015, the 2030 Agenda for Sustainable Development was adopted, including Sustainable Development Goals (SDGs) related to biodiversity. This agenda provides a renewed framework for addressing these issues, particularly through Goals 14 and 15, which focus on life underwater and on land, respectively (Obrecht et al., 2021; UN, 2015). Reaffirmed at COP 29 in 2024, the Kunming-Montreal Global Biodiversity Framework, first released in 2022, sets ambitious targets to halt biodiversity loss and guide global efforts until 2030 (Chandrasekhar et al., 2024).

The main drivers of biodiversity loss include: changes to and loss of natural habitats (land and sea), overexploitation, climate change, pollution and invasive alien species (IPBES, 2019). The leading force of global biodiversity loss is the transformation of land and marine environments, mainly resulting from the expansion and intensification of agriculture and livestock production. Direct exploitation through activities like fishing, logging, hunting, wildlife trade, etc. follows closely as another major driver of biodiversity loss (Jaureguiberry et al., 2022).

In summary, human activities are fundamentally reshaping our planetary systems, making biodiversity loss one of the most urgent environmental issues (UN, 2021). To deal with this pressing issue, it is essential to implement effective strategies that address the key drivers of biodiversity loss. Raising public awareness and fostering support for biodiversity conservation are crucial steps toward ensuring a sustainable future (UN, 1992, 2015).

1.1 The Role of Species Knowledge in the Context of Biodiversity Loss

The profound and accelerating loss of biodiversity underscores the need for strategies that not only address its direct drivers but also engage society in its conservation. A critical component of such engagement is the promotion of species knowledge, particularly among younger generations, to provide them with the awareness and motivation needed to conserve biodiversity (Melis et al., 2021). As Bebbington (2005) aptly noted, we cannot expect individuals to care for or make responsible decisions about the natural world if they are unable to recognise even the most common organisms around them. This sentiment is consistent with the idea that ‘we cannot protect what we do not know’ (Balmford et al., 2002).

Species knowledge is usually defined as the recognition and naming of different species (e.g., Randler, 2008a). The term species identification is often used interchangeably to describe the same concept (e.g., Gerl et al., 2021; Melis et al., 2021). Yet, some researchers have expanded the conception of species knowledge to encompass background information about a species (Lindemann-Matthies, 2010; Waliczek et al., 2017). To clarify the distinction between this deeper understanding and basic recognition and naming, Hooykaas et al. (2019) coined the term *species literacy*. This concept emphasises a broader understanding of a species, including its ecological role, natural habitat, life cycle, behaviour and origin, as well as its rarity or abundance. According to Hooykaas et al. (2019), species literacy involves different dimensions of learning. It contains not only factual knowledge about species, but more generally awareness and profound knowledge about their context. It includes additional practical skills and competencies like the ability to observe species in the wild, as well as successful application of this knowledge. Species knowledge in a narrow sense has been found to predict deeper understanding and contributes to species literacy. Therefore, individuals with greater species knowledge tend to have higher levels of in-depth species knowledge (Hooykaas et al., 2022). In the following, I use the term *species knowledge* defined ‘as the recognition and correct naming of a species’ (Härtel, Randler, & Baur, 2023), if referring to birds, I will use *bird species knowledge*.

Recent studies typically use a partial credit model to measure species knowledge. This model, developed by (Eschenhagen, 1982), differentiates between naming the correct species and identifying a higher taxonomic level. This scoring system is more effective in describing participants’ species knowledge than a dichotomous scoring system. If participants can at least identify the genus or family name of an animal, they demonstrate a better level of species knowledge than those who cannot identify the species at all (Gerl et al., 2018). Consequently, many studies in recent years have awarded 0.5 points for correctly naming the order and 1.0 points for correctly identifying the species name (e.g., Randler, 2008a).

Firstly, species knowledge is fundamental to understanding biodiversity, ecosystems and basic biological concepts, and is therefore essential in the context of biodiversity loss. Species could be conceptualised as the basic units of biology (Skarstein & Skarstein, 2020) and are certainly more tangible than the more complex and abstract ecological construct *biodiversity* (Bartkowski et al., 2015; Randler, 2008a; Van Weelie & Wals, 2002). To understand the interconnectedness of living organisms with each other and their environments, often described as the ability to *read nature* (Magnatnorn & Helldén, 2007; Somaweera et al., 2010), there is a need for people to be able to identify species and understand their roles. Species knowledge also enables people to grasp the complexity of biodiversity and to determine how ecosystems rely on this diversity (Bashan et al., 2021; Gerl et al., 2021). It is also a useful tool for teaching ecology. Particularly among students, recognising and understanding local species can inspire curiosity and can encourage them to explore broader environmental questions (Magnatnorn & Helldén, 2005). This helps cultivate interest in biodiversity and environmental issues, linking personal curiosity to larger conservation goals (Palmberg et al., 2015).

Secondly, species knowledge is an essential component of conservation efforts. For instance, promoting the knowledge of birds has been found to enhance people’s readiness to pay for parks and other green spaces, which in turn contributes to conservation (Caula et al., 2009). In addition, the knowledge of bird species enhances the cultural value that people attach to green spaces and, hence, the value they place on biodiversity (Cox & Gaston, 2015). Thus, species knowledge also builds on people’s capacity to value biodiversity correctly and strongly supports public consent for conservation plans (Dallimer et al., 2012). Besides this, species knowledge allows people to make ethical decisions about the use of natural resources after considering various factors, which often leads to sustainable consumption and usage (Wolff & Skarstein, 2020). Research has further demonstrated that children’s willingness to protect wildlife is positively linked to their species knowledge (J. Xu & Jiang, 2022). This is consistent with the broader view that increasing environmental knowledge can significantly influence people’s pro-environmental attitudes (e.g., Indriani et al., 2019; Roczen et al., 2014; S. Smith & Paladino, 2010). Pro-environmental or eco-centric attitudes are characterised by a worldview that favours to life in harmony with nature (Bogner & Wiseman, 1999). Such attitudes are crucial in addressing biodiversity loss, as they reduce negative human impacts on ecosystems (Montana & Mlambo, 2019). Furthermore, pro-environmental attitudes are frequently linked to sustainable behaviour (e.g., Handayani et al., 2021), although barriers such as personal costs may limit the full translation of attitudes into behaviour (Wyss et al., 2022). Importantly, individuals with pro-environmental attitudes are more likely to support conservation policies (Rohrschneider & Miles, 2015). Evidence also suggests that greater species knowledge fosters positive attitudes and empathy toward animals (e.g., Liordos et al., 2018; Melis et al., 2021), which are associated with stronger pro-environmental attitudes (Berenguer, 2007; Ienna et al., 2022). Deeper knowl-

edge of individual species, often referred to as species literacy (Hooykaas et al., 2019), has been linked to pro-environmental attitudes (Waliczek et al., 2017). As species knowledge encompasses aspects of species literacy (Hooykaas et al., 2022), this raises a crucial question: To what extent does species knowledge itself influence pro-environmental attitudes? Although the relationship between species knowledge and pro-environmental attitudes appears promising, research in this area remains limited (Härtel, Randler, & Baur, 2023). Filling this gap is essential to understanding whether improving species knowledge can contribute to the development of pro-environmental attitudes and, in the long run, support the achievement of conservation goals.

Third, the ability to identify species is crucial in the early detection and management of invasive species, identified as a driver of biodiversity loss. Invasive species often outcompete native flora and fauna, leading to ecosystem imbalances and a decline in biodiversity (Mollot et al., 2017). Early identification of these species is essential for preventing their spread and mitigating their impact (Genovesi & Monaco, 2013). Species knowledge enables individuals – ranging from citizens to professionals – to recognise invasive species before they become established in new areas. Concerned citizens are frequently the first to notice and report signs of invasive species and their spread (Howard et al., 2022; B. A. Johnson et al., 2020). Hence, species knowledge is a powerful tool in combating invasive species and fighting biodiversity loss (USDA, 2024).

Fourth, species knowledge contributes to the development of future taxonomists and species experts. Just as many species are threatened with extinction, taxonomy as a discipline is threatened by a global shortage of trained taxonomists (e.g., Engel et al., 2021; Wheeler et al., 2004). In 2020, government signatories to the CBD recognised this challenge and called it the *taxonomic impediment* (CBD, 2020). Taxonomic research is vital because there are countless species yet to be discovered or described. Alarmingly, some species may face *silent extinction* – disappearing without being formally identified or studied (Moura & Jetz, 2021). The work of identifying, classifying, and documenting species is fundamental to monitoring population declines and informing conservation strategies (Sandall et al., 2023).

Becoming a taxonomic expert requires extensive training, often beginning in childhood (Frobel & Schlumprecht, 2016), as the cognitive ability to distinguish between species develops at an early age (Tomkins & Tunnicliffe, 2015). However, effective learning in taxonomy is greatly enhanced by having a qualified mentor, and the scarcity of such mentorship opportunities exacerbates the current taxonomic crisis. To address this, future efforts must emphasise the development of species knowledge through collaborations between nature organisations, schools, and universities (Frobel & Schlumprecht, 2016). Early exposure to species identification and classification is essential to stimulate interest in taxonomy and to guide young people to become experts in this critical field (Hong et al., 2022).

Finally, species knowledge plays a vital role in enhancing personal well-being by fostering joy, curiosity, and pride, as demonstrated when students successfully identify plants and animals during field trips (Helldén & Helldén, 2008). These positive experiences are enhanced in biodiverse environments, as people who spend time or live in more species-rich ecosystems are reported to be healthier and have greater well-being (Dallimer et al., 2012; Díaz et al., 2006). Cox and Gaston (2015) further revealed that the more species a person can recognise and identify in their surroundings, the greater their reported well-being. However, biodiversity loss threatens these benefits by reducing opportunities for engagement, a phenomenon known as the *extinction of experience*. As people lose direct interactions with nature, their connection to the natural world weakens, as does their motivation to protect it (Gaston et al., 2020). In this context, species knowledge is crucial, as it enables individuals to identify and engage with the species still present in their environment, helping to preserve the emotional and mental benefits that biodiversity offers and motivating efforts to conserve what remains.

In conclusion, species knowledge is essential to tackling biodiversity loss. It plays a central role in Education for Sustainable Development (ESD), which is aligned with SDG 4 ('Quality Education') and focuses on equipping people with 'knowledge, skills, values, and ability to tackle issues such as climate change, biodiversity loss, overuse of resources, and inequality that impact the well-being of people and the planet' (UNESCO, 2021).

1.2 Birds as a Model for Species Knowledge

Many previous studies on species knowledge have focused on bird species, for several reasons. One key factor is that research suggests that individuals with a strong knowledge of bird species are likelier to possess accurate knowledge of other vertebrates and invertebrates. Thus, enhancing bird species knowledge may effectively improve overall species knowledge (Härtel, Randler, & Baur, 2023). Another important aspect is that bird species are strongly interconnected within ecosystems, making them invaluable for understanding and addressing biodiversity loss (Lees et al., 2022).

Bird species are highly reliable indicators of biodiversity and ecosystem health, and there is a well-established database of bird population trends. With approximately 10,000 species worldwide, their global distribution and diversity allow for broad monitoring across various habitats (Fraixedas et al., 2020; Lees et al., 2022). Birds often inhabit higher trophic levels, making them sensitive to changes such as prey availability (Gregory et al., 2005). As they respond predictably to environmental changes, such as habitat loss and climate shifts, they provide early warnings of ecosystem health (Pereira & Cooper, 2006). Extensive monitoring programmes have been established globally, supported by skilled volunteers, who

regularly count bird populations, ensuring consistent and reliable data collection (Gregory et al., 2005; Venier & Pearce, 2004). In addition, our substantial understanding of their population biology, behaviour, and life history makes them great indicators, particularly in temperate regions (Venier & Pearce, 2004; Xiao et al., 2017).

Birds are also fundamental to all four categories of ecosystem services. They provide food through meat, eggs, and sometimes also nests (Lees et al., 2022). Further, bird guano is a valuable natural fertiliser, and feathers are used for insulation, bedding, and ornamentation (Green & Elmberg, 2014). Birds regulate and control pest populations, e.g. rodents in farmlands, helping to reduce the reliance on chemical pesticides (Kross et al., 2016). They further contribute to pollination, seed dispersal, and scavenging, all of which help maintain ecosystem health, regenerate habitats, and cycle nutrients back into the environment (Whelan et al., 2015). Birds provide supporting services by acting as ecosystem engineers, creating habitats for other species and enhancing biodiversity. Their migratory behaviour facilitates environmental teleconnections, linking ecosystems across vast distances (Lees et al., 2022). Finally, research has shown that bird species richness is linked to higher levels of life satisfaction among Europeans, highlighting their cultural and psychological value (Methorst et al., 2021). By fostering birdwatching and ecotourism, birds further contribute to cultural ecosystem services (Kronenberg, 2014; Sekercioglu, 2002). Their symbolic and aesthetic value inspires art, literature and spiritual practices worldwide (e.g., D'coutho, 2016).

Sadly, global bird populations are under significant pressure, with nearly half of all bird species worldwide experiencing declines (Lees et al., 2022). In Europe, 13% of bird species are threatened (BirdLife International, 2021), and the native avifauna of the European Union faces severe losses, with breeding bird abundance having declined by 17-19% since 1980, equivalent to 560-620 million fewer bird individuals (Burns et al., 2021). In Germany, numbers of common farmland birds such as the Northern Lapwing (*Vanellus vanellus*) have declined by over 80% due to intensified land use, a trend that has accelerated since 2000 (Kamp et al., 2021). In summary, the invaluable ecological, cultural, and economic roles of birds, coupled with alarming population declines, underscore the urgent need for targeted conservation efforts to protect these important indicators of biodiversity and ecosystem health.

For the same reasons, birds make ideal models for studying species knowledge and its role in fostering pro-environmental attitudes (Gerl et al., 2018; Whelan et al., 2015). Their high visibility, predominantly diurnal behaviour, and noteworthy activity patterns make them particularly easy to observe, count, and study (Lees et al., 2022; Lopez et al., 2020; Sullivan et al., 2009). In everyday life, people have easy access to biodiversity thanks to the many bird species that live in urban environments (Lopez et al., 2020). With a relatively stable taxonomy and a manageable number of species, especially in regions such as Europe (Caula et al., 2009; Gerl et al., 2018), birds serve as an ideal cognitive entry

point for developing species identification skills. Their presence in gardens and urban green spaces provides abundant opportunities for outdoor learning activities, such as field trips and environmental education programmes (Kahn, 2020).

Birds are one of the most charismatic taxonomic groups (Hummel et al., 2015) and are highly appreciated by the general public (Belaire et al., 2015; Carver, 2009). Their appeal makes them ideal representatives of endangered species in environmental education, raising interest and awareness of conservation (Brambilla et al., 2013). For this reason, birds are often used as flagship species in marketing campaigns (Garnett et al., 2018).

Birds are also a central focus of Citizen Science (CS), with a global community of volunteers whose contributions are invaluable in monitor populations and ecological trends (Tubelis, 2023). For many, birdwatching is a passionate hobby that fosters an understanding of biodiversity and supports large-scale conservation initiatives (Sullivan et al., 2014). These qualities make birds not only effective subjects for advancing scientific understanding of ecosystems, but also model organisms for studying and improving species knowledge and support for conservation.

Recent studies on bird species knowledge have used different strategies to select species for their surveys, as summarised in Table 1.2.1. The predominant approach is an abundance-based selection, which prioritises species frequently observed in particular regions or gardens (e.g., Evans et al., 2006; Prokop & Rodák, 2009). For example, studies by Cox and Gaston (2015) and R. L. White et al. (2018) focused on birds commonly found in United Kingdom (UK) gardens. Similarly, some studies chose species based on high observation counts from CS programmes, such as the Garden Birdwatch organised by the German conservation organisation Naturschutzbund (NABU) and the Big School Birdwatch run by the Royal Society for the Protection of Birds (RSPB) in the UK (Enzensberger et al., 2022; R. L. White et al., 2018; Zahner et al., 2007). Another common approach is to rely on previous studies, such as Gerl et al. (2018), who adapted species lists from Zahner et al. (2007) and included additional species based on species characteristics. Some studies, like Zahner et al. (2007), used expert ratings where species were selected based on expert assessments of their recognisability from species commonly identified in CS projects. Additionally, studies such as Sturm et al. (2020) emphasised the use of distinctive visual or acoustic species characteristics. The number of bird species included in the knowledge tests varies widely, ranging from a minimum of 6 species (Ehlers Smith et al., 2021) to a maximum of 28 species (Randler & Heil, 2021). However, none of the studies provide an explicit reason for the selection of these specific numbers.

These approaches to species selection are not only applicable to studies on bird species but also extend to research on species knowledge across various taxa (e.g., Hooykaas et al., 2019). For example, Bashan et al. (2021) also interviewed experts, such as ornithologists and botanists to select the species for their survey. Several studies have proposed alterna-

tive strategies for species selection beyond the criteria outlined in Table 1.2.1. Schlegel and Rupf (2010) suggest including flagship species in the selection process. Using a different approach, Gerl et al. (2021) emphasise the importance of selecting species representing distinct ecosystems, providing a broader ecological context. Additionally, studies by Härtel, Randler, and Baur (2023) and Randler (2008a) draw on popular science literature, such as Schmid’s ‘100 Animals One Should Know’ (2001), while Palmberg et al. (2015) employed school textbooks as a basis for species selection.

Table 1.2.1: Selection criteria for bird species in different studies on bird species knowledge. The criteria mentioned in these studies were grouped into 5 categories: (1) abundance; (2) previous studies; (3) expert assessment; (4) species characteristics; (5) taxonomic coverage.

Study	Number of Bird Species	Selection Criteria	Category
Evans et al., 2006.	18	Birds commonly found in UK gardens, lowlands and shores.	Abundance
Zahner et al., 2007	12	Expert rating workshop based on the most common 30 species identified from NABU’s Garden Birdwatch (a CS event).	Expert assessment
Prokop & Rodák, 2009	25	Except of 3 species, birds are common in Slovakia (Bird Atlas, Balla et al., 2002).	Abundance
Cox & Gaston, 2015	14	Birds commonly found in UK gardens.	Abundance
Gerl et al., 2018	15	Species based on Zahner et al. (2007), with three additional species chosen for their visibility and body size.	Previous studies and species characteristics
R. L. White et al., 2018	12	Birds commonly found in UK gardens, focusing on species frequently reported in the RSPB’s Big School Birdwatch (a CS event).	Abundance
Sturm et al., 2020	8	Frequently observed bird species in the study area, selected for their visual or acoustic distinctiveness and comparability with other studies.	Abundance, previous studies and species characteristics

Study	Number of Bird Species	Selection Criteria	Selection Category
Randler & Heil, 2021	28	Selected using previous studies (Randler, 2008a), based on abundance and taxonomic representation of bird orders in Germany (Breeding Bird Atlas, Gedeon, 2015).	Abundance and taxonomic coverage
Ehlers Smith et al., 2021	6	Large terrestrial bird species common throughout the study region.	Abundance and species characteristics
Enzensberger et al., 2022	15	Species with the highest observation counts in the NABU's Garden Birdwatch (a CS event), following criteria from Gerl et al. (2018) and Zahner et al. (2007).	Abundance and previous studies
Ortega-Lasuen et al., 2023	10	Common bird species widely observed in the study area.	Abundance

Although abundance-based selection is a common strategy, there are several limitations introducing biases into assessments of bird species knowledge. For example, population size is negatively correlated with body size (Blackburn & Gaston, 1996), leading to the overrepresentation of smaller species in surveys. Additionally, population size is influenced by phylogenetic relationships; for example, in Germany, swallow species (*Hirundinidae*) like the Common House Martin (*Delichon urbicum*) and the Barn Swallow (*Hirundo rustica*) are both abundant and share similar traits due to close kinship (Gedeon, 2015). This can lead to an overrepresentation of closely related groups, limiting diversity in the species selected.

Using CS data for species selection may further bias species selection by favouring large and conspicuous species and by over-representing birds from easily accessible habitats such as footpaths and wetlands (Callaghan et al., 2021; Tiago et al., 2017). Similarly, relying on garden bird counts tends to prioritise songbirds and urban species and exclude other familiar orders such as waterfowls (*Anseriformes*). This method may also benefit garden owners, who, through repeated encounters, are more experienced in identifying these species (Cox & Gaston, 2016). To mitigate these biases, species selection should involve multiple selection categories and a variety of habitats to ensure a more representative assessment of species knowledge. For example, combining analyses of different CS databases, breeding bird data, school textbooks, and previous studies with expert ratings could ensure that the species selected for a bird species knowledge survey are well-chosen and representative

in terms of abundance, habitat, visibility, prominence, etc. Such a selection can then be used as an appropriate baseline of what species the general public should know to assess their level of bird species knowledge.

1.3 Bird Species Knowledge in Adults and Children and the Influence of Demographic Variables

In Germany, Enzensberger et al. (2022) found that adults correctly identified an average of 46% of 15 bird species, with the Eurasian Blackbird being the best-known species. Similarly, Randler and Heil (2021) observed that university staff and students identified 58% of 28 species.

In the UK, the European Robin (*Erithacus rubecula*) and Eurasian Blackbird (*Turdus merula*) were the best-known bird species, with nearly 90% of participants correctly identifying them (Cox & Gaston, 2015). However, overall species recognition in the UK was lower, with adults identifying only 34% of four bird species in a test by Dallimer et al. (2012), which applied a stricter binomial scoring system requiring participants to provide the exact species name for a correct answer. In the Netherlands, Hooykaas et al. (2019) recorded a mean identification score of 69% for 13 native species, with high familiarity for the European Robin (92%) and low recognition for the Long-tailed Tit (*Aegithalos caedatus*) (18%).

Further south, Ehlers Smith et al. (2021) assessed bird knowledge in grassland communities in South Africa, where identification rates ranged from 24% for the Southern Bald Ibis (*Geronticus calvus*) to 59% for the Secretarybird (*Sagittarius serpentarius*). According to Celis-Diez et al. (2017) Chilean participants correctly identified only two out of ten species, indicating low overall identification rates. The Austral Thrush (*Turdus falcklandii*) was the most commonly identified bird, whilst only 1% of participants identified nine out of ten species.

School students generally show lower bird species knowledge compared to adults. Early studies in Germany, such as Eschenhagen (1982), found the European Robin to be the best-known bird species at the species level among students in grades¹ 5 and 9, while the Mallard (*Anas platyrhynchos*) (or ‘duck’) was the best-known at the higher taxonomic level. Zahner et al. (2007) surveyed students in grades 4, 7, and 12, revealing that they could identify about one-third of 12 bird species. However, compared to Eschenhagen’s (1982) study, Zahner et al. (2007) showed a decline in knowledge for four out of five bird species, despite an increase in knowledge of the Eurasian Blackbird. Gerl et al. (2018) similarly found that school students aged 6-19 identified about one-third of 15 bird species. A follow-up of Zahner et al.’s (2007) survey revealed a 20% decline in bird identification

¹The grade levels refer to the following ages: grade 1 \approx 6 years old up to grade 12 \approx 17-18 years old.

scores among secondary students over a decade. A study conducted by Sturm et al. (2020) reported that grade 7 students identified an average of 25% of 8 bird species, with the House Sparrow (*Passer domesticus*) and Eurasian Blackbird being the most familiar. Gerl et al. (2021) found that students aged 11-13 identified 42% of 10 species, reflecting a 7% decrease compared to Randler's (2008a) study, nevertheless the Eurasian Blackbird remained the best-known species.

Outside Germany, Egger et al. (2024) revealed that United States (US) high school students (ages 14-18) identified 35% of 21 bird species, with the Blue Jay (*Cyanocitta cristata*) being the best-known. In Slovakia, Prokop and Rodák (2009) reported that elementary and middle school students (grades 5-9) had a mean identification score of 39%, with the Black Woodpecker (*Dryocopus martius*) being the best-known out of 25 species. The study employed binomial scoring. In the UK, Evans et al. (2006) showed that students aged 7-16 identified 31% of 18 bird species. The most commonly identified species was the European Robin (92.3%), followed by the Eurasian Blackbird (75.2%). Similarly, R. L. White et al. (2018) found that UK students aged 7-10 had a 36% identification score for 12 species, with the European Robin as the best-known bird. Hooykaas et al. (2019) assessed bird species knowledge among Dutch primary school students (aged 9-10, grade 4), indicating an average identification rate of 35% for 13 bird species. The European Robin (40%) was the best-known species, followed by the Common Magpie (*Pica pica*) (23%). In Spain, 12-15-year-old students identified one-third of 10 bird species correctly, with the Greylag Goose (*Anser anser*) being the best-known (Ortega-Lasuen et al., 2023).

In general, species knowledge varies between taxa, with birds often outperforming other groups such as plants and invertebrates (Jaun-Holderegger et al., 2022). Studies show that both adults and children tend to have better knowledge of animals, especially vertebrates, than plants (e.g., Bebbington, 2005). Mammals have the highest reported identification rates of any vertebrate group (e.g., Gerl et al., 2021). Across all taxa, exotic species are often better known than native species (Genovart et al., 2013).

Bird species knowledge among adults and children is shaped by various demographic factors including age, gender, education and geographical location. Age plays a significant role as older individuals generally have greater bird species knowledge (e.g., Enzensberger et al., 2022; Hooykaas et al., 2019), which is likely due to longer exposure to nature and continuous learning over time (Randler & Heil, 2021). Also, students in higher grades seem to perform better on bird species identification tests (Eschenhagen, 1982; Zahner et al., 2007). However, some studies have identified different peaks in the students' bird species knowledge, such as Randler (2008a) finding the highest level at age 14, and Gerl et al. (2018) observing peaks at ages 10, 15, and 19.

In addition, gender differences in bird species knowledge have been observed, with men often outperforming women in bird identification tests (e.g., Ehlers Smith et al., 2021; Hooykaas et al., 2019; Randler & Heil, 2021). However, some studies report no significant

gender differences (Cox & Gaston, 2015). Among school students, girls tend to perform better in bird identification than boys, as noted in German studies by Randler (2008a) and Zahner et al. (2007). In contrast, Eschenhagen (1982) found that boys in grade 5 outperformed their female counterparts.

Moreover, education also has a strong influence on species knowledge: adults with higher levels of education typically demonstrate better bird species identification skills (e.g., Hooykaas et al., 2019). However, some studies have found no significant educational differences (Enzensberger et al., 2022). Among school students, those in advanced academic tracks or those attending higher-performing schools tend to achieve higher identification rates (Randler, 2008a; Zahner et al., 2007).

Geographical location is another key factor. Adults living in rural areas or smaller towns generally have better bird species knowledge than those living in urban areas (e.g., Enzensberger et al., 2022). Randler and Heil (2021) showed that adults living closer to green spaces scored higher on bird identification tests. Rural residents were also more knowledgeable about the birds in their neighbourhood compared to urban residents (Vázquez-Plass & Wunderle Jr., 2010). Conversely, studies by Gerl et al. (2018, 2021) showed that school students in larger cities had higher species knowledge, while Egger et al. (2024) found no differences regarding hometown size. Ortega-Lasuen et al. (2023) reported that students from rural backgrounds tend to have better bird species knowledge, possibly due to the distance to natural areas rather than population size (Randler & Heil, 2021). Additionally, both adults and children who have garden at home generally perform better on bird identification tests than those without (e.g., Hooykaas et al., 2019; Randler & Heil, 2021; Zahner et al., 2007). However, no study has yet assessed the impact of the frequency of garden visits, as having a garden does not necessarily imply frequent use.

The results of these studies reveal inconsistent effects of demographic factors on bird species knowledge reflecting similar inconsistencies observed in animal species knowledge research more generally (e.g., Gerl et al., 2021). It would be valuable for future studies to expand their focus to include individual factors, such as personal interests, in order to better understand the underlying mechanisms that shape species knowledge.

Variability in identification scores across studies is further compounded by differences in study design and testing methods. Studies vary in the species and number of species included, as well as in scoring systems, with the majority using partial coding (e.g., Hooykaas et al., 2019), but some using more rigorous binomial coding (e.g., Dallimer et al., 2012). These methodological differences hinder direct comparisons and make it difficult to assess trends in species knowledge over time.

While some researchers (e.g., Genschel, 1950; Frobel & Schlumprecht, 2016) have hypothesised a decline in species knowledge in recent decades, robust evidence remains limited. For German school students, both Zahner et al. (2007) and Gerl et al. (2018, 2021) noticed

a decline in bird species knowledge. However, Zahner’s (2007) study focused on a different age group, and both researchers assessed fewer species compared to the studies they used for comparison, which makes direct comparisons between the studies challenging. If confirmed, this could contribute to the *shifting baseline syndrome*, in which gradual losses in ecological knowledge and awareness lead to diminished perceptions of biodiversity. This syndrome normalises biodiversity loss as each generation compares only the small changes they experience, unaware of the more significant losses over multiple generations (Baum & Myers, 2004; Leather & Quicke, 2009).

1.4 Individual Factors That Influence Bird Species Knowledge

To effectively promote bird species knowledge in the future, it is crucial to identify and understand the wide range of factors that influence it. While recent studies on species knowledge have focused primarily on demographic variables, they often overlook individual factors such as personal interests and perceptions (e.g., Ehlers Smith et al., 2021). Evidence of the impact of these factors is provided by Gerl et al. (2021), who found that school students with a strong affinity for playing in natural environments consistently outperformed their peers in species knowledge tests. Additionally, membership in nature organisations has been consistently associated with higher levels of species knowledge among children and adults compared to non-members (Enzensberger et al., 2022; Jaun-Holderegger, 2019). These findings highlight the need for a more comprehensive investigation of individual-level factors to better understand their role in shaping bird species knowledge.

Perceptions of birds may significantly influence bird species knowledge by shaping the way individuals interact with and value these animals. Positive perceptions, such as appreciating birds for their songs, beauty, or the feelings they evoke when observing them, can enhance human-nature interactions and foster support for conservation efforts (Belaire et al., 2015). In urban settings, where most human-nature interactions now occur, residents often value birds in their neighbourhoods, viewing them as a link to nature and an opportunity to engage with local biodiversity (Belaire et al., 2015; Randler, 2010). Research has shown that the likeability of birds is associated with bird species knowledge; for example, Cox and Gaston (2015) found that people tend to be better at correctly identifying songbirds they like, while negative correlations were observed for non-songbirds. Similarly, R. L. White et al. (2018) reported a positive relationship between children’s likeability of birds and their bird species knowledge. Appreciation of birds could also encourage behaviours like establishing bird habitats or birdwatching, potentially enhancing their knowledge of various bird species even more (Goddard et al., 2013). However, the extent to which perceptions of

birds can lead directly to knowledge is still underexplored, so further research is needed into themes such as how emotional and aesthetic appreciation feeds into species learning.

Interest in birds appears to be a predictor of bird species knowledge, yet its effects among various age groups remain largely unexamined. Achievement emotions such as interest are closely linked to activities that demand effort and engagement, such as learning or studying (Pekrun et al., 2002). Interest encourages participation in activities that present novelty or challenges (Gläser-Zikuda et al., 2005) and acts as a vital motivator for knowledge acquisition, inspiring individuals to actively pursue information about subjects that captivate them (Ainley et al., 2002; Harackiewicz et al., 2016). Empirical studies support this link between interest and species knowledge. For instance, interest in nature is positively correlated with the species knowledge of student teachers in Norway (Palmberg et al., 2015). Similarly, university staff and students with a stronger interest in birds demonstrate higher levels of bird species knowledge (Randler & Heil, 2021). Members of conservation organisations, who often have a personal interest in birds, tend to outperform the general public in bird species identification (Prokop et al., 2015). Furthermore, for birdwatchers, the desire to improve birding skills is a key motivation linked to achievement (Randler, 2023b). However, the relationship is not always straightforward; for example, students' bird species knowledge does not necessarily reflect an interest in birds (Hummel et al., 2015). In light of the findings, further research is needed to clarify the extent to which interest in birds influences bird species knowledge in both children and adults.

Individual differences in recreational activities can strongly impact bird species knowledge. Animal-related activities provide hands-on, immersive and informal learning experiences that enhance understanding of species (Randler, 2010; Schwichow et al., 2016). Repeated observations of animals, such as insects or birds, have been shown to enhance individual species knowledge (Cosquer et al., 2012; Cox & Gaston, 2016; Gerl et al., 2018). Participation in CS programmes further enables structured observation, with contributors demonstrating higher bird identification skills and knowledge (Cooper et al., 2007; Randler, 2021b). Visits to zoos and natural history museums similarly facilitate learning about biodiversity and conservation, often resulting in species knowledge gained as a by-product (Fukano et al., 2021; Lindemann-Matthies & Kamer, 2006; Randler, 2010). Moreover, bird feeding provides close contact with local wildlife, enabling individuals to regularly observe and distinguish between bird species (Cox & Gaston, 2016). Students who have access to bird feeders have shown higher scores in bird identification tests (Zahner et al., 2007), and regular bird feeding has been linked to greater bird species knowledge (Cox & Gaston, 2015; Enzensberger et al., 2022). Further, it can be assumed that installing nesting boxes may also enhance bird species knowledge by enabling long-term observation of specific species. While recreational activities involving animals have been shown to influence general species knowledge, the specific impact of activities (such as nature observation, zoo or

museum visits, installation of nesting boxes, and bird feeding) on bird species knowledge remains underexplored, in both children and adults. Future research is needed to better understand the extent and nature of these effects.

Even though it is well-known to affect our environmental attitudes and behaviours, the role of connectedness to nature in shaping species knowledge is still a largely overlooked aspect of biodiversity research. Defined as the emotional and cognitive bond between individuals and the natural world, connectedness to nature captures the extent to which people feel part of nature and perceive it as integral to their identity (Mayer & Frantz, 2004; Schultz, 2002). This connection has been shown to promote psychological well-being, reduce anxiety, and foster pro-environmental attitudes and behaviours (Barrable & Booth, 2020; Capaldi et al., 2015; Cox & Gaston, 2016). While connectedness to nature is strongly associated with these broader environmental outcomes, its relationship with specific forms of environmental knowledge, such as species knowledge, remains unclear. In particular, studies have found only weak correlations between connectedness to nature and environmental knowledge (Roczen et al., 2014; F. G. Kaiser et al., 2008), which includes species knowledge as one of its components (Kai et al., 2014). However, empirical evidence suggests that direct experience with nature can facilitate species learning, such as bird identification (Kuo et al., 2019). As connectedness to nature is a strong predictor of pro-environmental attitudes and behaviours (Barrable & Booth, 2020; Kleespies et al., 2021), and these attitudes may be linked to bird species knowledge (see Chapter 1.1), it is essential to understand the role of connectedness to nature in the interplay between bird species knowledge and environmental attitudes. Future research should investigate whether strengthening connectedness to nature can simultaneously increase bird species knowledge and promote pro-environmental attitudes, providing dual benefits for conservation education and conservation policy.

In summary, bird species knowledge might be influenced by a complex interplay of individual factors, including perceptions, interests, recreational activities, and connectedness to nature. To understand these dimensions not only advances our knowledge of how species learning occurs but also provides valuable insights for education and conservation initiatives aimed at improving pro-environmental attitudes and fostering environmental stewardship.

2 Research Objectives

Species knowledge is essential for effective biodiversity conservation, as individuals who cannot identify even common species are unlikely to make responsible choices or show concern for the natural world (Balmford et al., 2002). Although a decline in species knowledge among younger generations is often assumed (e.g., Schulte et al., 2019), this has not yet been robustly tested empirically. In this thesis, birds were used to assess species knowledge, as they are a particularly well-suited taxonomic group due to their high visibility, the public interest they generate, and their ecological importance.

The primary aim of this thesis is to assess the current level of bird species knowledge among the public (school students and adults). It will also determine whether species knowledge has indeed decreased in younger generations, and therefore compare current levels of knowledge among school students with those of almost 20 years ago. In addition, as previous research has largely focused on demographic predictors of bird species knowledge, this thesis aims to explore how individual factors contribute to bird species knowledge. Furthermore, this thesis aims to find out whether and to what extent bird species knowledge predicts environmental attitudes and how the connectedness to nature is linked within this setting of influential factors and effects. These insights are crucial for developing effective strategies to promote species knowledge, especially through ESD, which helps people make informed decisions, engage responsibly with nature, and contribute to long-term biodiversity conservation (Navarro-perez & Tidball, 2012).

However, before bird species knowledge can be assessed, a standardised baseline of bird species that should be known by the general public is needed. Existing studies lack consistency in species selection, making comparisons difficult due to differences in the number and types of species included. In addition, many studies have used only one or two criteria for species selection (e.g., abundance, garden bird counts), leading to biases in the assessment of species knowledge. The first task of this thesis is therefore to provide an informed and methodologically rigorous basis for the selection of bird species to be used in knowledge surveys, thus ensuring a more representative and comparable framework for future research.

To conclude, this thesis aims to:

- Develop a methodology for selecting species in species knowledge studies.
- Identify which bird species should be known by the general public.
- Assess the current level of bird species knowledge among school students and adults.
- Examine the factors influencing bird species knowledge in school students and adults.
- Explore the impact of adults' bird species knowledge on their environmental attitudes.
- Compare the current level of bird species knowledge among school students with that of students in the early 2000s.
- Investigate the sources from which school students acquire bird species knowledge.

3 Research Papers

3.0 Overview of the Studies

Study I laid the foundation for subsequent studies by selecting bird species that should be known by the general public. This was achieved through a comprehensive database review combined with two expert assessments, resulting in the so-called ‘golden 50’ species list. This list ensures both taxonomic representation and societal relevance. In addition to its methodological value for species selection, the list serves a variety of purposes, such as helping to pick flagship species for conservation. Most importantly, the list provides a well-supported basis for valid comparisons and informed conclusions about bird species knowledge and its broader implications.

Study II assessed the current level of bird species knowledge among adults, along with the factors that shape it and its influence on environmental attitudes. To measure bird species knowledge, the ‘golden 50’ list was applied in a nationwide survey of 3,438 adults in Germany. Using structural equation modelling, the results show that interest in birds and participation in animal-related activities lead to greater bird species knowledge, which in turn promotes pro-environmental attitudes.

In Study III, the ‘golden 50’ list was reduced to 30 species to cope with the shorter attention span of school students. The study examined the bird species knowledge of 1,752 students from 17 schools in the federal state of Baden-Württemberg, Germany. It investigated the factors influencing students’ bird species knowledge and compared current knowledge levels with those in 2005. The results indicate that students are more adept at identifying birds at higher taxonomic levels than at species level. In addition, a significant decline in students’ bird species knowledge was observed between 2005 and 2022/2023. The study also identified the main sources of students’ species knowledge, highlighting the crucial role of family in shaping their understanding of birds.

3.1 Study I: Selection of Indicator Bird Species as a Baseline for Knowledge Assessment in Biodiversity Survey Studies.

Simple Summary

Knowledge about species has been surveyed many times in research in the past. To our knowledge, species selection has never been properly justified and there is no consensus on which species should be used as a baseline for knowledge about species in the public. Based on database analysis and two expert panel studies, a list of 50 bird species (occurring in Germany) is provided at the end of this paper. The list can be used by educational institutions, for example, but also for research to make studies about knowledge about species more comparable in the future.

Abstract

The loss of Earth's biodiversity is accompanied by a loss of public knowledge about species. Many scientists are convinced that knowledge about species is an important prerequisite to interest and investment in species conservation. In the past, knowledge about species has mostly been assessed using birds, but there is no consensus on which birds could serve as a baseline for knowledge about species in the general public. The aim of this study is to provide a list of the 'golden 50' bird species in Germany that can be used by educational institutions, as well as studies about species knowledge to make them more comparable. The list can also serve as a basis for the selection of so-called flagship species, which are used for the protection of habitats and other species due to their high likeability. To achieve this, three consecutive steps were conducted: an analysis of bird-related databases to determine which species might be common and known and two expert panel studies. The data analysis included several factors: species characteristics, Citizen Science data, public value and importance, and scientific studies. In both the first and second rounds, experts were asked for their opinion on which species should be known by the general public in Germany. The first expert panel, which consisted of only a small group of experts ($n = 6$), was mainly used to reduce the number of species for the second panel. In the second expert panel, 197 ornithologically qualified experts from all over Germany were asked for their assessment. The correlations between the expert assessments and the different variables were all significant (except for the species trait 'colourfulness'), which validates the selection process used here and consequently the species list that has been compiled. The selection process can also be applied to other biogeographical regions or taxa.

Keywords: knowledge about species; expert rating; bird species; citizen science; knowledge survey

Introduction

Recent decline in bird populations is one of the many components of the biodiversity crisis (Lees et al., 2022). The latter is particularly caused by humans, as natural resources are overexploited (Ikpa, Dera, & Jande, 2010), habitats are destroyed and fragmented (Keil et al., 2015), and human–wildlife conflicts are arising (Nyhus, 2016). Together with climate change, this will most likely accelerate species extinction in the future (Rull, 2022). The decline in biodiversity is accompanied by a decline in knowledge about avian species identification (Gerl et al., 2021) as well as deeper knowledge about ecology and natural history (e.g., about their habitat; Hooykaas et al., 2019). This, in turn, is linked to a loss of the experience of nature, for example, listening to birdsong (Gaston et al., 2020). We are thus faced with a triad of declines, in bird species, knowledge of birds, and experience with them.

Knowledge about species, understood as the identification and naming of species (Randler, 2008a), is important from many perspectives. For one, knowledge of species strengthens the connection to nature and counteracts the currently declining perception of natural elements (so-called plant/nature blindness) (Bakar et al., 2020; Cox & Gaston, 2015). A lack of knowledge about species also makes it difficult to understand the systematics of organisms (Shipley & Bixler, 2020). In addition, knowledge of species is important for a deeper understanding of ecology and serves as a starting point for an understanding of biodiversity (Lindemann-Matthies, 2010; Magntorn & Helldén, 2007). The importance of knowledge about species for nature conservation and environmental protection is particularly relevant in regard to the biodiversity crisis. Knowledge about species is an important prerequisite for the protection of biodiversity (Leather & Quicke, 2009), and high knowledge about species also implies higher environmental awareness (Härtel, Randler, & Baur, 2023). People with a high level of knowledge about species also have more positive attitudes towards animals (Hosaka et al., 2017), which is important when it comes to protecting certain animal species (Prokop et al., 2013). Due to the decline in bird populations, their conservation is extremely important (Lees et al., 2022). Birds serve as indicators of the biodiversity of an ecosystem (Gregory et al., 2003), and they also provide some important ecosystem services including the eating of pests, the pollinating of flowers, and the dispersal of seeds (Whelan et al., 2015). Thus, knowledge of bird species is important for bird conservation.

Knowledge about bird species must therefore be fostered in the future, regardless of formal education or informal learning settings. Many studies on knowledge about bird species have been carried out in recent years, (e.g., Enzensberger et al., 2022; Sturm et al., 2020), although there are some precursors in earlier times (Randler, 2008a, 2002). Yet, the species surveyed in these studies are often not uniform and there is no consensus on which bird species a person should be able to identify. This makes the studies difficult to compare and strengthens the need for a baseline of bird species to improve them. Hence, it is important to find out which species can serve as a baseline for knowledge about species

and as representatives of species diversity. The curricula of educational institutions could then be adapted to this. In addition, a baseline of species might help to record changes in knowledge about species over time, thus making studies on knowledge about species more comparable. These studies are also very important because they often link knowledge about species with personal factors, e.g., interests and attitudes (Cox & Gaston, 2015; Randler & Heil, 2021), and thus address the question of the best way to promote knowledge about species. Furthermore, such a baseline of bird species could also be used for selecting so-called ‘flagship species’ that are important for conservation purposes (Randler, Staller, et al., 2023).

Previous studies on knowledge based their bird species selection on a variety of different criteria, i.e., population size (Cox & Gaston, 2015; Gerl et al., 2021; Randler, 2008a), garden bird counts, Citizen Science (CS) data (Enzensberger et al., 2022; Hooykaas et al., 2019; Zahner et al., 2007), breeding bird surveys, or presence in school textbooks (Palmberg et al., 2015; Randler & Heil, 2021). However, in most studies on knowledge, the choice of species was based on only one or a few criteria. Thus, there is a lack of agreement and consensus about the species selection itself and even a lack of agreement about the procedure of species selection. To establish a baseline of species that can be used for studies or educational purposes, it is important to refer to a variety of criteria in order to induce as little bias in the selection as possible and adequately represent bird biodiversity.

The shortcoming when focusing only on population size, for example, is that population size is negatively related to body size (Blackburn & Gaston, 1996), and selecting this as an indicator will result in the selection of smaller species because there are many more individuals of a smaller species in a given geographic range. Furthermore, population size is influenced by phylogeny. In the example of parids (family: *Paridae*), all species in Germany are closely related, have a similar size (due to phylogenetic relationship), and three of them are among the most abundant birds in Germany (Gedeon, 2015). In turn, larger body size may be associated with the prevalence of CS data because larger birds are reported significantly more often (Callaghan et al., 2021). Thus, when participants do not use a complete checklist, where all species seen and heard are counted, but instead use presence-only (or ad libitum) reporting, on average participants report larger bird species out of proportion to their rate of observation. Correspondingly, CS data are overrepresented near footpaths and wetlands (Tiago et al., 2017), meaning that the different habitats influence the CS data. It thus becomes clear that species selection should not be based on population size or CS data solely, as this creates a bias regarding the size and kinship or habitat of species. Additionally, some studies on knowledge about species based their selection on garden bird counts. Basing studies mainly on garden bird count data (Hooykaas et al., 2019; Zahner et al., 2007) can bias the species selection towards songbirds, diurnal species, and urban birds (garden birds), and this usually excludes well-known orders such as duck or owl species (simply because ducks and owls do not usually visit feeders). By focusing only on

garden birds, an advantage for garden owners is also created as they are more likely to know the species than others due to frequent sightings (Cox & Gaston, 2016). More specifically, people who own a garden may score higher in their initial basic knowledge about bird species (Randler & Heil, 2021). Hence, covering several habitats is recommended, to give people who spend more time in forests or urban parks than in the garden a chance to show their knowledge. This does not mean that previous studies have been flawed in any way, but rather that the species serving as a baseline for knowledge about species should be well chosen and that more criteria should be used for species selection to reflect the diversity of birds.

Aim of the Study

The aim of this study is therefore to provide a list of the ‘golden 50’ bird species that is considered as a baseline for knowledge about bird species (see Step III for the reasoning behind the number of species). Here, for the first time, we present a selection procedure based on a variety of databases and two expert panel studies. The selection process applies to German species but can be transferred to any other biogeographical region and even to other taxa. Thus, it can be considered a template for further studies carried out in a similar manner elsewhere in the world. We analysed bird-related databases such as CS online platforms (Club 300, eBird, Ornitho, Garden Birdwatch (NABU)), breeding bird data (Breeding Bird Census (ADEBAR¹)), as well as bird-related books, previous studies, and the Bird of the Year election (NABU). We, therefore, acknowledge both the scientific basis of birds and their representation in society, and we add the human dimension to the selection procedure. The methods of this paper are based on three studies: Step I: Data Analysis, Step II: Expert Rating 1, and Step III: Expert Rating 2. An overview of the methodological approach is shown in Figure 3.1.1.

¹Atlas Deutscher Brutvogelarten (Gedeon, 2015).

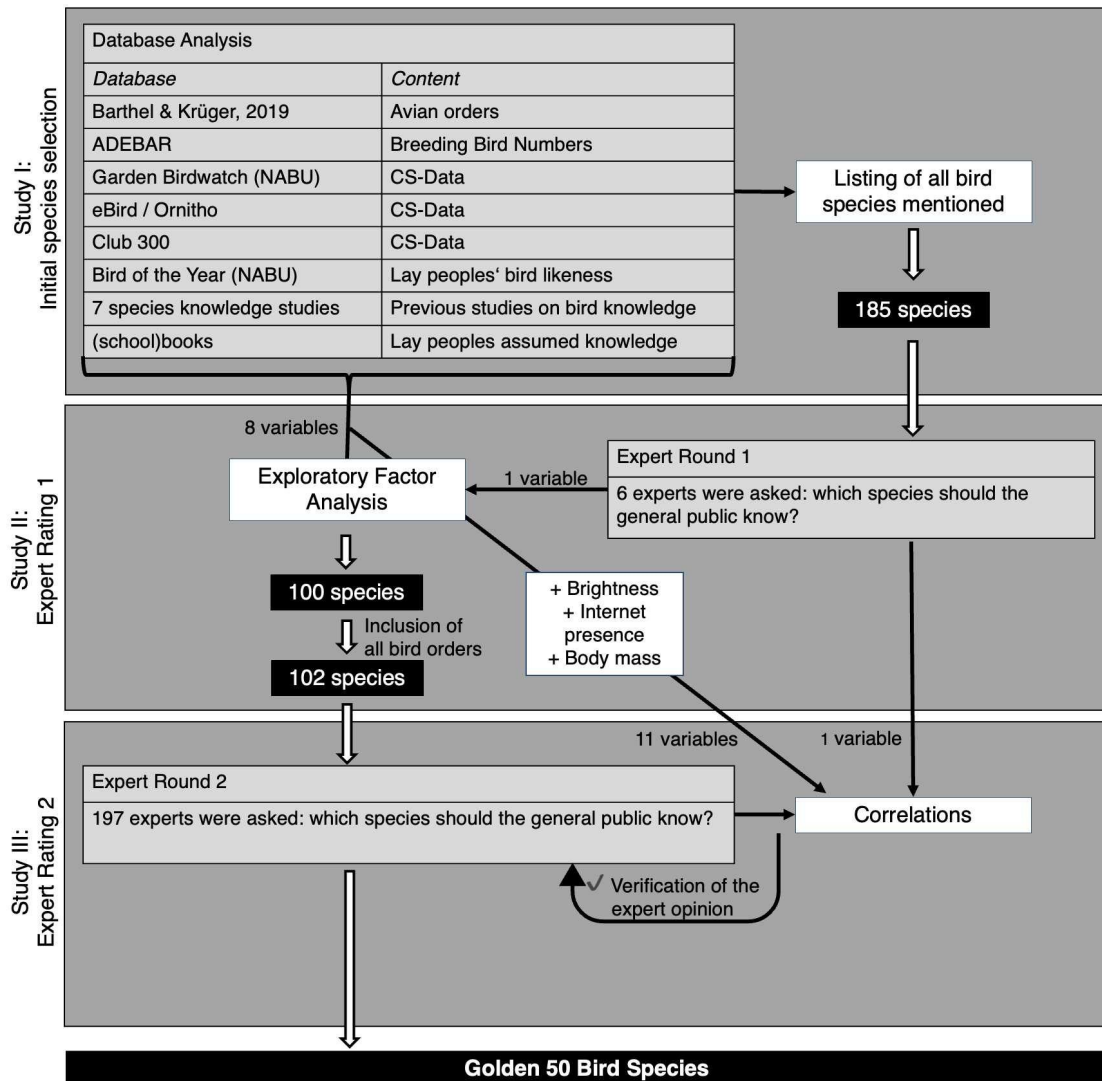


Figure 3.1.1: Overview of the methodological approach, divided into Step I (upper box), Step II (middle box), and Step III (lower box). The lightgrey boxes describe what was done in each step of the selection, the white boxes describe the associated statistical approaches. The black boxes refer to the number of species as a result of each step.

Material and Methods

Step I: Initial Data Analysis for the Expert Rating

In order to establish a general baseline of common and possibly known bird species, several bird-related databases were consulted according to certain criteria. The data mostly relate to population sizes, CS platforms, the popularity of bird species, previous studies on knowledge about species, and birds in the literature. A more detailed description of the databases and criteria used is given below. Only bird species included in the official German bird list (Barthel & Krüger, 2019) were used. Since 1800, 527 bird species have been reported in Germany, of which 250 breed here (Barthel & Krüger, 2019).

1. Avian orders: We used at least one species from each avian order reported in Germany (Barthel & Krüger, 2019); however, 5 orders were excluded due to their rare occurrence or extremely localized distribution (see Table 3.1.1 for details). Correction for Passeriformes: As songbirds (Passeriformes) make up the largest proportion of extant bird species (more than 50% (Manegold et al., 2004)), 86 songbird species were selected, with at least one species from each songbird family (with a few exceptions), to represent each family (Table 3.1.1).

2. Breeding Bird Numbers: The 118 most common breeding bird species were selected based on the German Breeding Bird Census ADEBAR (Gedeon, 2015). Species with a population size larger than 10,000 (measured based on breeding pairs, territories, etc.) were used. Where a range was given, the lowest level was used. This selection is based on a nationwide breeding bird mapping, and it reflects the breeding avifauna. However, some species that fall within the range of the above criteria are largely unknown and poorly observed (e.g., the Eurasian Woodcock (*Scolopax rusticola*)) but were retained in our first round of selection. Depending on the population size, each species received the following rank: 1. >10,000; 2. >100,000; 3. >1 million.

3. Citizen Science data – Garden Birdwatch: CS data come in a variety of forms, from low-level engagement projects (counting garden birds) to more complex and advanced projects (e.g., ringing programmes). The representation of bird species in the general population was used as an additional criterion. Here, we used the CS element of the Garden Birdwatch ('Stunde der Gartenvögel'), which requires only one hour of bird-watching and is open to everyone (Hooykaas et al., 2019). This event is run by the nature conservation organisation (NGO) NABU, which has a strong base in Germany and in which the German birding scene has its roots. The species recorded during these days can be considered as species that the general public and less trained birders can encounter and identify daily. We used the 130 most common species from this event. The data are based on ranks, with rank 1 = the most commonly reported species.

4. Citizen Science data – eBird and Ornitho: More complex CS programmes are the online platforms eBird (eBird.org) and Ornitho (ornitho.de). People who use these platforms tend to have higher knowledge and more skills than birders who do not use them

(Randler, 2021b). Although these data are extremely useful for scientific analyses, they are slightly biased towards species near wetlands, species near footpaths (Tiago et al., 2017), and larger species (Callaghan et al., 2021). These data reflect the bird species encountered and reported by experienced observers, including summering and wintering species, but also migrants. The use of data from these platforms ensured that non-breeding species were included. The 100 species most commonly reported in Germany from eBird and 50 from Ornitho, extracted on 16 July 2022, at 12:10, were used (data is freely available on the platform). Data were ranked, with rank 1 = the most commonly reported species.

5. Citizen Science data – Club 300: Another association providing a platform for bird-watchers is the Club 300 Germany (Randler, 2023a). The platform has a membership fee of only 15 euros per year, which means that no one is excluded from the platform by their financial situation. This platform aims to improve the rapid transmission of information on the occurrence of rare bird species. Club 300 comprises the most knowledgeable and highly specialised birders in Germany (Randler, 2021a, 2023a). However, the requirement to have seen at least 300 bird species in Germany to be admitted to Club 300 has been lifted for a while now. Consequently, there are also members with less than 100 species on the life list in Club 300 (Randler, 2023a). We used the Club List, i.e., the list of all bird species seen in Germany by at least one member of Club 300. We then selected the 100 species that have been seen by the highest number of Club 300 members, extracted on 16 July 2022, at 12:49 (data is freely available on the platform). Based on the number of observers of a species, a rank (1–18) was assigned to it, whereby rank 1 = highest number of observers.

6. Lay peoples’ bird preference: In 2021, the NGO NABU (see above) launched a unique challenge to select the most popular bird species in Germany. Based on this selection, the annual election of the Bird of the Year was then organized. Normally, the choice is made by a small commission of experts or by the general public on the basis of a pre-selection. In 2021, any bird species could be nominated and lay people as well as members of NABU were invited to take part. This vote can be seen as a representation of the status of a species in the eyes of the public and provides an alternative view in addition to the scientific census methods and CS data. Here, we have used the first 50 species selected on the basis of their rank, with rank 1 = the most popular species.

7. Previous studies on bird knowledge: As previous studies have already addressed bird species and public knowledge, we added the species that have been already used by Gerl et al. (2021), Randler (2008a), Randler and Heil (2021), Sturm et al. (2020), Cox and Gaston (2015), Hooykaas et al. (2019), Jaun-Holderegger (2019), Wolff and Skarstein (2020), and Skarstein and Skarstein (2020) to the list. This list comprises all available studies covering the topic in Europe published with a presentation of the respective selected species. Data from Randler (2008a) and Randler and Heil (2021) as well as from Wolff and Skarstein (2020) and Skarstein and Skarstein (2020) were combined because these data were from the same research groups, so each research group could only contribute once

to the dataset. Data were based on the number of research groups in whose studies a respective species was used (coded from 0–7, where 0 = used by no research group and 7 = used by 7 research groups).

8. Lay peoples' assumed knowledge: As a supplement, we used a popular German public book '100 species everyone should know' (Schmid, 2001), which covers a wide range of vertebrates and invertebrates; a basic bird identification book (covering 85 bird species; Haag, 2017), and three school textbooks from grades 5 and 6 (Drös et al., 2001; Höfer et al., 2016; Randler et al., 2004), as birds are especially mentioned in the curricula for these grades. In addition, we used a school textbook from 1933 (Schwenk & Jäckle, 1933). This was done to consider what was taught in school at this time, as knowledge about species is often transferred across generations. We analysed all books for the bird species they contained. The data were based on the number of mentions (coded from 0–6, with 6 = mentioned in all books).

The first step was to search the databases for all species that met the criteria described above. All species that fulfilled the criteria were collated in the first round. To check whether our selection reflects avian diversity, we compared the number of species per order reported in Germany (Barthel & Krüger, 2019) with the number of species per order on our list. For this, a chi-square test was performed in SPSS 28 to see if the number of species per order differs between the entire German list and our reduced list. This can be seen as a test of whether the selection in the list remains representative.

Table 3.1.1: Overview of all bird orders and families, with the respective number of species in the initial selection (Step I), as well as the number of species after Step II and in the ‘golden 50’ species list. The reasoning for an order/family (for *Passeriformes*) being not included is also given.

Order	Families in this Order (Number of Species in the Initial Selection)	Reason If Not Included in the Initial Selection	Number of Species in Germany	Number of Species in the Initial Selection	Number of Species after Study II	Number of Species in the ‘Golden 50’
Galliformes	Phasianidae		8	5	2	1
Anseriformes	Anatidae		53	21	7	4
Caprimulgiformes	Caprimulgidae		2	1	1	0
Apodiformes	Apodidae		5	1	1	1
Otidiformes	–	only found in three federal states; very low breeding population of 114 individuals	–	–	–	–
Cuculiformes	Cuculidae		3	1	1	1
Pterocliiformes	–	not breeding in Germany, no records in the last 10 years	–	–	–	–
Columbiiiformes	Columbidae		7	5	4	2
Gruiformes	Rallidae, Gruidae		13	4	3	2
Podicipediformes	Podicipedidae		6	3	2	1
Phoenicopteriformes	–	limited breeding range; naturalised population, less than 20 pairs	–	–	–	–
Charadriiformes	Burhinidae Haematopodidae Recurvirostridae Charadriidae Scolopacidae Glareolidae Laridae Stercorariidae Alcidae		114	18	4	2
Gaviiformes	–	only rare winter visitors	–	–	–	–
Procellariiformes	–	very restricted range to island of Heligoland	–	–	–	–
Ciconiiformes	Ciconiidae		2	2	1	1
Suliformes	Sulidae, Phalacrocoracidae		5	2	1	1
Pelecaniformes	Threskiornithidae, Ardeidae, Pelecanidae		13	3	2	1
Accipitriformes	Pandionidae, Accipitridae		27	11	4	2
Strigiformes	Tytonidae, Strigidae		12	6	2	0
Bucerotiformes	Upupidae		1	1	1	0
Coraciiformes	Coraciidae, Alcedinidae, Meropidae		4	2	1	1

Order	Families in this Order (Number of Species in the Initial Selection)	Reason If Not Included in the Initial Selection	Number of Species in Germany	Number of Species in the Initial Selection	Number of Species after Study II	Number of Species in the 'Golden 50'
Piciformes	Picidae		10	7	3	2
	Falconidae		9	4	1	0
	Psittaculidae		1	2	1	0
Passeriformes	Laniidae	Some families excluded a priori because of extremely limited breeding ranges or low population size	8	1	1	0
	Vireonidae		2	0	0	0
	Oriolidae		1	1	1	0
	Corvidae		10	7	7	5
	Bombycillidae		1	1	1	0
	Paridae		7	6	5	2
	Remizidae		1	0	0	0
	Panuridae		1	0	0	0
	Alaudida		9	3	1	1
	Hirundinidae		5	3	2	2
	Cettiidae		1	0	0	0
	Aegithalidae		1	1	1	1
	Phylloscopidae		15	3	2	1
	Acrocephalidae		13	6	1	0
	Locustellidae		5	1	0	0
	Sylviidae		12	4	4	1
	Regulidae		2	2	2	0
	Troglodytidae		1	1	1	1
	Sittidae		1	1	1	1
	Tichodromidae		1	0	0	0
	Certhiidae		2	2	1	0
	Mimidae		1	0	0	0
	Sturnidae		2	1	1	1
	Turdidae		18	5	4	2
	Muscicapidae		24	12	6	3
	Cinclidae		1	1	1	0
	Passeridae		4	2	2	1
	Prunellidae		4	1	1	0
	Motacillidae		15	6	3	1
	Fringillidae		20	11	9	4
Calcariidae	2	0	0	0		
Emberizidae	16	4	2	1		
Parulidae	2	0	0	0		

Step II: Expert Rating 1

The initial list contained 185 species and was presented to a small group of experts ($n = 6$) in a second step. The experts were asked for their opinion on which species should be known by the general public (in Germany). With this question, we wanted to obtain an individual assessment of the experts, almost as a supplement to the data analysis. These experts were chosen because they were all members of Christoph Randler's Lab, and thus, were ornithologically versed and birdwatchers. The instruction was to mark at least one species per order, and as the order *Passeriformes* provided the most species of the initial selection, the experts were asked to mark one species per family in this order. In total, a maximum of one hundred species could be selected by each expert, but it was also possible to mark a smaller number of species. Each expert worked alone. The expert panel consisted of 2 males and 4 females, either experts in geoecology/ecology/ornithology (2 B.Sc.², 1 M.Sc.³) or biology education (2 M.Ed.⁴ in formal, 1 M.Ed. in non-formal education). These individuals were informed that their expert help would be needed to prepare the subsequent larger expert assessment. The experts in this first initial panel have experience with birds and birding in all parts and federal states of Germany, covering eastern, western, northern, and southern Germany, including some months or years of working/living in these different regions. In addition, students from Christoph Randler's field ornithology course were asked to make similar assessments at the end of the summer term, first individually and then in small groups (total $n = 26$). The students had learned about bird identification from different lecturers since the beginning of their studies and had some experience in teaching school children as pre-service teachers. We followed the approach of the wisdom of the crowd (Krause et al., 2010) and aggregated the data from the 26 students into one single score. Hence, they were treated as an additional expert to reflect the students' opinions and not outweigh the other experts. In total, therefore, seven expert assessments were used in this step (six people plus one aggregated score from the students). Each species could then receive a score between 0 (not mentioned at all) and 7 (mentioned by all). This expert assessment was then included as a dimension in the exploratory factor analysis (EFA). In this way, the social expertise was already added to a small extent in the first reduction of species.

SPSS 28 was used for the statistical analysis. To reduce the initial selection of 185 species to around 100 for the second panel of experts, we applied a factor analysis to the species and their characteristics. EFA helps to produce a more practical dataset by reducing the number of variables. More specifically, the manifest variables should be reduced to a small set of latent variables that explain as much of the variance in the outcome variables as possible. The starting point of EFA is an orthogonal decomposition of an input matrix. This

²Bachelor of Science.

³Master of Science.

⁴Master of Education.

results in an output matrix made up of orthogonal components (factors) that maximise the variation in the manifest variables. Thus, the EFA almost always results in a smaller number of factors (Boslaugh, 2012). In this way, the EFA was used to reduce the number of bird species.

For the EFA, we used the eight data sources of Step I (eBird, Ornitho, Club 300, Garden Birdwatch (NABU), Breeding Bird Census (ADEBAR), previous studies, books, Bird of the Year (NABU)) and the expert assessment as well. More specifically, we used the ranks, categories, and numbers already described above and included them in the factor analysis. Typically, EFAs overestimate the number of factors to be extracted when the decision is based on the eigenvalue greater than one criterion. To get a better estimate of the number of factors to be extracted, we performed a parallel analysis (Patil et al., 2017). This parallel analysis helps to decide how many factors to extract and generates a random dataset and random eigenvalues. These random values are then compared with the values obtained from the EFA. The number of the factors to be extracted is the number for which the eigenfactors of the EFA are higher than the eigenfactors of the parallel analysis (Patil et al., 2017). We used a principal component EFA with varimax rotation. In addition, we repeated the EFA without the data from expert round 1 to assess whether experts are needed to establish a species selection. To compare the ranks resulting from EFA 1 and EFA 2, a Wilcoxon signed-rank test was performed. After Step I, a chi-square test was calculated to test whether the reduced list still represents the avian diversity in Germany.

Step III: Expert Round 2

A second expert assessment was used for a further reduction to 50 species. It followed the wisdom of the crowd approach (Krause et al., 2010), i.e., the idea that a given number of expert opinions represents the ‘true’ value. We did two analyses in this expert round. First, a quality check of our experts, and second, the reduction of the species set. This reduction was the main aim of expert round 2, but nevertheless, we present some basic demographic data and validity on our experts.

For the expert assessment, people throughout Germany were contacted who generally have a high level of ornithological knowledge (due to their profession or leisure activities). These included students, postgraduates, or university staff in biological disciplines, members of nature conservation organizations or ornithological working groups and associations, employees of nature conservation authorities, and experts from ornithological internet platforms.

For this second expert panel, the reduced list of bird species from expert panel 1 was presented in an anonymous online survey⁵. The experts were asked whether they thought the following bird species should be known to the general public (in Germany). The response options were either yes, probably, or no. Each ‘yes’ was coded as 1, each ‘no’ as -1, and each

⁵The questionnaire can be found in the Appendix (Study I – A3).

‘probably’ as 0. In addition, the experts were allowed to indicate other species that they considered relevant. After rating the species, the participants were also asked to provide some information about themselves (gender, age, highest level of education) or their qualifications as an expert (e.g., whether they are a teacher, members of a nature conservation organisation). In addition, participants’ birding specialisation was assessed using a 5-item scale (c.f. Randler & Heil, 2021). Birding specialisation refers to the knowledge of bird species and is self-reported. Participants had to indicate the number of species they could identify by sight or by song without any help, give a self-assessment of their ornithological skills on a scale from 1 = novice to 5 = expert, and answer two questions on behaviour, i.e., the number of field trips and the number of days out. Previous work has shown that self-reporting is a highly reliable measure of knowledge, and the self-assessment of birding specialisation was highly correlated with a subsequent knowledge test ($r = 0.729$, $p < 0.001$; Randler & Heil, 2021, see also Rögele et al., 2022). Thus, respondents can accurately assess their knowledge. The number of 50 species was chosen because we felt it reflects bird diversity in Germany well. So far, a maximum of 28 species have been surveyed in studies on knowledge (Randler & Heil, 2021), but in order to not neglect people who know more than 28 bird species, a higher number of species is recommended (Randler, 2021b). To not scare people off, the questionnaire should have a comfortable length, which is why we see 50 species as a good number.

Testing the Suitability of the Expert Round 2:

A correlation was calculated to examine the extent to which the assessment of the second expert panel was related to the variables of the initial preselection. For this purpose, some information derived from the databases was subject to more detailed assessment. This applies to the eBird, Ornitho, Club 300, the NABU, and the ADEBAR databases. For eBird and Ornitho, the exact number of reported observations was now used. Furthermore, each of the species was assigned a category based on the number of observations made by Club 300 members (on 16 July 2022). Depending on how many observers a species had, it was assigned a category. Four species had the most observers overall and thus received category 1 (547 observers). The Eurasian Nightjar (*Caprimulgus europaeus*) received category 81 with the smallest number of observers (440 observers). Each species was also ranked according to its position in the 2021 Bird of the Year and the Garden Birdwatch 2022 election of the NGO NABU. For the number of breeding pairs in Germany, the estimated number, according to the ADEBAR (Gedeon, 2015), was used for each species in the second round. In addition to the databases from the first round, further variables were correlated with the expert assessment 2: data on the colourfulness (c.f. Randler, Staller, et al., 2023), the body mass data from Ladle et al. (2019), and the internet presence of the bird species, as well as the result of the expert assessment 1. The colourfulness of a species was assessed following the criteria of Randler, Staller, et al. (2023), who showed that the assessment of colourfulness by a few experts correlates with the opinion of the

general public. Consequently, a colourfulness index was created for each bird species on the list (number between 1 = very dull to 5 = very striking). To determine the web presence of a species, the number of web pages it is mentioned in was assessed using an automated and depersonalised web search (using the Google Custom Search API⁶). For this purpose, German species names were used and the Google hits were restricted to Germany. Synonymous species names were also used, and the number of hits was added. It was expected that the web presence would give a value reflecting the importance of a species to humans. The German names in this study follow Barthel and Krüger (2019), and the English names were extracted from eBird.org. These correlations aimed to find out whether there is a relationship between all the above-mentioned variables, which reflect the popularity and abundance of bird species in society, and the expert assessment. It also allowed us to test whether an expert assessment is a suitable tool for compiling a species list. SPSS 28 was used for the statistical analysis. We used non-parametric tests (Spearman-Rho) to assess relationships and t-tests to compare groups. As after Step I and II, a chi-square test was calculated to test whether the reduced list still represents the avian diversity in Germany.

⁶Application Programming Interface

Results

Step I: Initial Data Analysis for the Expert Rating

The data analysis based on the above-mentioned criteria resulted in an initial list of 185 bird species (see Appendix (Study I – A1)). This was achieved by adding up all the bird species that have been identified in the process. To be included in our initial list, a bird species had to be mentioned in at least one of our eight categories from above. Because this initial selection includes scientific approaches (e.g., breeding bird mapping), CS data, general public views, human dimensions, and more societal approaches, many topics dealing with birds have been considered. This selection was used to inform the second step of the reduction, the expert assessments. The avian diversity in Germany was equally represented in the selection ($\chi^2 = 29.100$, $df = 24$, $p = 0.216$), and the selection can be considered representative in the numbers of species per order.

Step II: Expert Round 1

The EFA 1 (including the expert opinion) showed eigenvalues of 4.705 and 1.227, while the random eigenvalues were 1.346 and 1.221, suggesting a single-factor solution. When applying the EFA 2 without the expert opinion, eigenvalues were 4.079 and 1.221 (for all factor loadings, see Table 3.1.2). In EFA 1 and EFA 2, the loadings were below the usual threshold (<0.45 , see Comrey & Lee, 1992) for Bird of the Year and Club 300 members. Nevertheless, we kept the data from these platforms in the analyses because they were based on a positive preselection. Based on this analysis, the standardised residuals were saved and ranked. High values of the standardised residuals (z-scores) indicate a high level of agreement between the species characteristics and the experts' responses (in case of EFA 1). More specifically, species with high z-scores occur frequently, are often reported on CS platforms, are liked, are well represented in literature/other studies, and were considered important to know by Round 1 experts. EFA 1 thus helps to reduce the number of species based on the criteria from Step I and the first expert panel. Comparing the ranks of EFA 1 with the ranks of EFA 2 (see Appendix (Study I – A2)), it becomes clear that the first 27 species were identically ranked and a further 3 species had the same ranking. Consequently, 30 species have identical rankings in the lists, and the remaining species mostly differ only slightly in their ranking. The Wilcoxon signed-rank test showed that the ranks resulting from the two EFA were not significantly different ($z = -0.327$, $p = 0.743$). Moreover, the correlation between both factor scores (standardised residuals) was extremely high ($r = 0.993$, $p < 0.001$, $n = 185$). Thus, it seems that the expert rating did not contribute much to the species selection.

Table 3.1.2: Factor loadings for step II. Column 2 lists the components of the EFA 1 with the experts, column 3 the components of the EFA 2 without experts. Negative loadings are found if ranks were used for the data source (because rank 1 was the most preferred/common species). The closer the loading is to the extreme value -1 or 1, the stronger the influence of the factor. The loadings can be interpreted as follows: > 0.71 (50% overlapping variance) = excellent, > 0.63 (40% overlapping variance) = very good, > 0.55 (30% overlapping variance) = good, > 0.45 (20% overlapping variance) = fair, and > 0.32 (10% overlapping variance) = poor (Comrey & Lee, 1992).

Data Source	Component (EFA 1 with Experts)	Component (EFA 2 without Experts)
Garden Birdwatch (NABU)	-0.842	-0.842
eBird	-0.833	-0.843
Expert Round 1	0.825	0.814
Books	0.822	-0.778
Ornitho	-0.779	-0.787
Previous Studies	0.774	0.771
Breeding Bird Census (ADEBAR)	0.743	0.771
Bird of the Year (NABU)	-0.380	-0.362
Club 300	-0.208	-0.217

The first 100 species with the highest residuals (z-scores) from EFA 1 were selected for the second expert panel. This resulted in the exclusion of one order (*Caprimulgiformes*) and one songbird family (*Bombycillidae*) which were not among the first 100 species. *Caprimulgiformes* and *Bombycillidae* each contain only one species occurring in Germany. The Eurasian Nightjar (*Caprimulgus europaeus*) is nocturnal, and the Bohemian Waxwing (*Bombycilla garrulus*) is an irregular/irruptive winter visitor. To include all orders and songbird families, they were added back to the species selection, resulting in 102 species being presented to the second round of experts. These species are listed in descending order in the Appendix (Study I – A2). We compared the number of species per avian order in Germany (Barthel & Krüger, 2019) against our selection of 102 species. The selection was representative ($\chi^2 = 36.107$, $df = 24$, $p = 0.054$).

Step III: Expert Round 2

Analysis of the Expert Responses:

In Step III, 197 experts took part in the online survey. The average age was 44.42 ± 16.23 years, with 73 females (37.1%), 123 males (62.4%), and 1 person who did not specify gender (0.5%). Participants were asked to indicate their qualification as an expert, e.g., birdwatcher or other. Multiple responses were possible. Most of the respondents reported that they were birdwatchers, followed by members of a nature conservation association or an ornithological working group (Figure 3.1.2A). The most commonly reported highest degree was a university doctorate. This was followed by a master's degree and diploma (Figure 3.1.2B). Birding specialisation was 20.91 ± 4.66 (out of a maximum of 28 and a minimum of 5 points, Figure 3.1.2C). There was no correlation between the birding spe-

cialisation score and the number of species selected, suggesting that more skilled people are aware of the difficulties of bird identification. Age was significantly negatively correlated with the number of species selected ($r = 0.204$, $p = 0.004$). Older respondents selected fewer species. Females selected a similar number of species as males ($T = 1.56$, $p = 0.12$).

Analysis of the Species:

On average, the experts selected 57.88 ± 13.27 species that should be known by the general public. The coding of the response options allowed us to calculate a rank for each bird species, potentially ranging from -197 (no expert thinks that people should know this species) to 197 (every expert thinks people should know this species). The species rankings are shown in Table 3.1.3. To compare the rank of the ‘golden 50’ species with the ranks from Step II, see Appendix (Study I – A2). However, Club 300 and body mass data were moderately positively correlated, and all other variables were strongly correlated with the expert assessment (Table 3.1.4). All correlations were significant except for colourfulness (Table 3.1.4). This means that the colourfulness of a species does not seem to influence the experts’ assessment. The experts mainly voted for species that are frequently reported on CS platforms, such as eBird and Ornitho (Figure 3.1.3). They also considered species that are frequently googled as important to know (Figure 3.1.3). The actual breeding bird population in Germany (ADEBAR) also correlates significantly positively with the expert assessment. Species with a high number of breeding pairs were rated as important to know by the experts. It is also clear that even the experts of panel 1 were able to accurately assess whether a respective species should be known or not, as the correlation between the two expert assessments was high. The significant positive correlation of body mass shows a tendency of the experts to select larger species.

Based on the results, the second expert assessment can be used to determine the selection of species for studies on knowledge about species. Some experts also mentioned additional species with the White-tailed Eagle (*Haliaeetus albicilla*) being the most frequently mentioned with 11 nominations. With 11 ‘yes’ votes, he would only reach 61st place and was therefore not included in the ‘golden 50’ selection. Considering these 50 species, the diversity in terms of species per avian order is representative of the German avifauna ($\chi^2 = 22.856$, $df = 24$, $p = 0.528$).

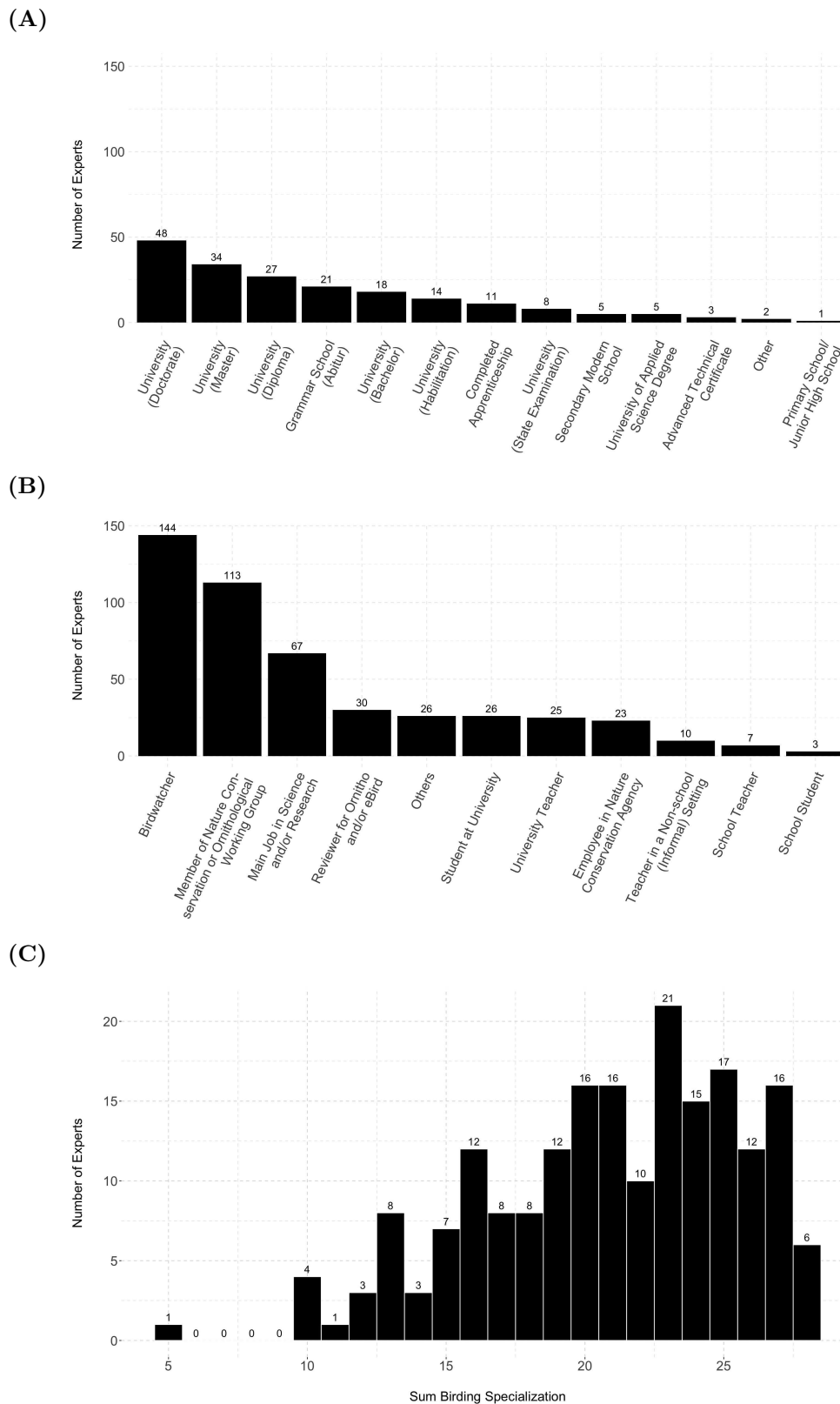


Figure 3.1.2: Analysis of the Experts of Step III: (A) Qualification as an Expert (multiple responses were possible) (B) Highest degrees of the Experts (C) Histogram of the Birding Specialisation of the Experts (5 Items; Maximum: 28 points (highly specialised), Minimum: 5 points (little specialised); Mean: 20.91 ± 4.66).

Table 3.1.3: Results of Step III: the ‘golden 50’ bird species as a baseline for knowledge about bird species. Answers of the experts were coded as follows: ‘yes’ = 1, ‘no’ = -1, ‘probably’ = 0, and the resulting sum was calculated for each species.

Rank	Species	Scientific Name	Sum
1	Common Magpie	<i>Pica pica</i>	197
2	Common Chaffinch	<i>Fringilla coelebs</i>	197
3	Eurasian Blackbird	<i>Turdus merula</i>	197
4	Great Tit	<i>Parus major</i>	196
5	White Stork	<i>Ciconia ciconia</i>	195
6	Eurasian Jay	<i>Garrulus glandarius</i>	195
7	Common Starling	<i>Sturnus vulgaris</i>	195
8	European Robin	<i>Erithacus rubecula</i>	195
9	Mute Swan	<i>Cygnus olor</i>	193
10	Great Spotted Woodpecker	<i>Dendrocopos major</i>	192
11	Eurasian Blue Tit	<i>Cyanistes caeruleus</i>	191
12	Mallard	<i>Anas platyrhynchos</i>	190
13	House Sparrow	<i>Passer domesticus</i>	188
14	Grey Heron	<i>Ardea cinerea</i>	185
15	White Wagtail	<i>Motacilla alba</i>	180
16	Barn Swallow	<i>Hirundo rustica</i>	178
17	Common Buzzard	<i>Buteo buteo</i>	178
18	European Goldfinch	<i>Carduelis carduelis</i>	175
19	Common House Martin	<i>Delichon urbicum</i>	167
20	Greylag Goose	<i>Anser anser</i>	165
21	Eurasian Wren	<i>Troglodytes troglodytes</i>	165
22	Eurasian Bullfinch	<i>Pyrrhula pyrrhula</i>	164
23	European Greenfinch	<i>Chloris chloris</i>	161
24	Eurasian Skylark	<i>Alauda arvensis</i>	160
25	Common Kestrel	<i>Falco tinnunculus</i>	158
26	Feral Pigeon	<i>Columba livia f. domestica</i>	158
27	Common Cuckoo	<i>Cuculus canorus</i>	154
28	Red Kite	<i>Milvus milvus</i>	151
29	Common Swift	<i>Apus apus</i>	150
30	Common Kingfisher	<i>Alcedo atthis</i>	148
31	Carrion Crow	<i>Corvus corone</i>	148
32	Black Redstart	<i>Phoenicurus ochruros</i>	146
33	Eurasian Nuthatch	<i>Sitta europaea</i>	144
34	Common Wood Pigeon	<i>Columba palumbus</i>	141
35	Eurasian Blackcap	<i>Sylvia atricapilla</i>	135
36	Yellowhammer	<i>Emberiza citrinella</i>	134
37	Northern Lapwing	<i>Vanellus vanellus</i>	133
38	Common Chiffchaff	<i>Phylloscopus collybita</i>	128
39	Great Cormorant	<i>Phalacrocorax carbo</i>	124
40	Eurasian Coot	<i>Fulica atra</i>	124
41	Eurasian Jackdaw	<i>Coloeus monedula</i>	121
42	European Green Woodpecker	<i>Picus viridis</i>	117
43	Common Crane	<i>Grus grus</i>	104
44	Common Nightingale	<i>Luscinia megarhynchos</i>	93
45	Black-headed Gull	<i>Chroicocephalus ridibundus</i>	92
46	Common Pheasant	<i>Phasianus colchicus</i>	92
47	Song Thrush	<i>Turdus philomelos</i>	87
48	Great Crested Grebe	<i>Podiceps cristatus</i>	77
49	Common Raven	<i>Corvus corax</i>	56
50	Canada Goose	<i>Branta canadensis</i>	41

Table 3.1.4: Correlations (Spearman-Rho) of the variables with the rank of the Expert Round 2 (Step III).

Data Source	r	p
Expert Round 1	0.813	<0.001
eBird	0.736	<0.001
Ornitho	0.708	<0.001
Google Search Results	0.703	<0.001
Garden Birdwatch (NABU)	-0.700	<0.001
Previous Studies	0.667	<0.001
Bird of the Year (NABU)	-0.634	<0.001
Books	0.613	<0.001
Breeding Bird Census (ADEBAR)	0.325	<0.001
Club 300	0.269	0.006
Body Mass	0.207	0.037
Colourfulness	0.069	0.491

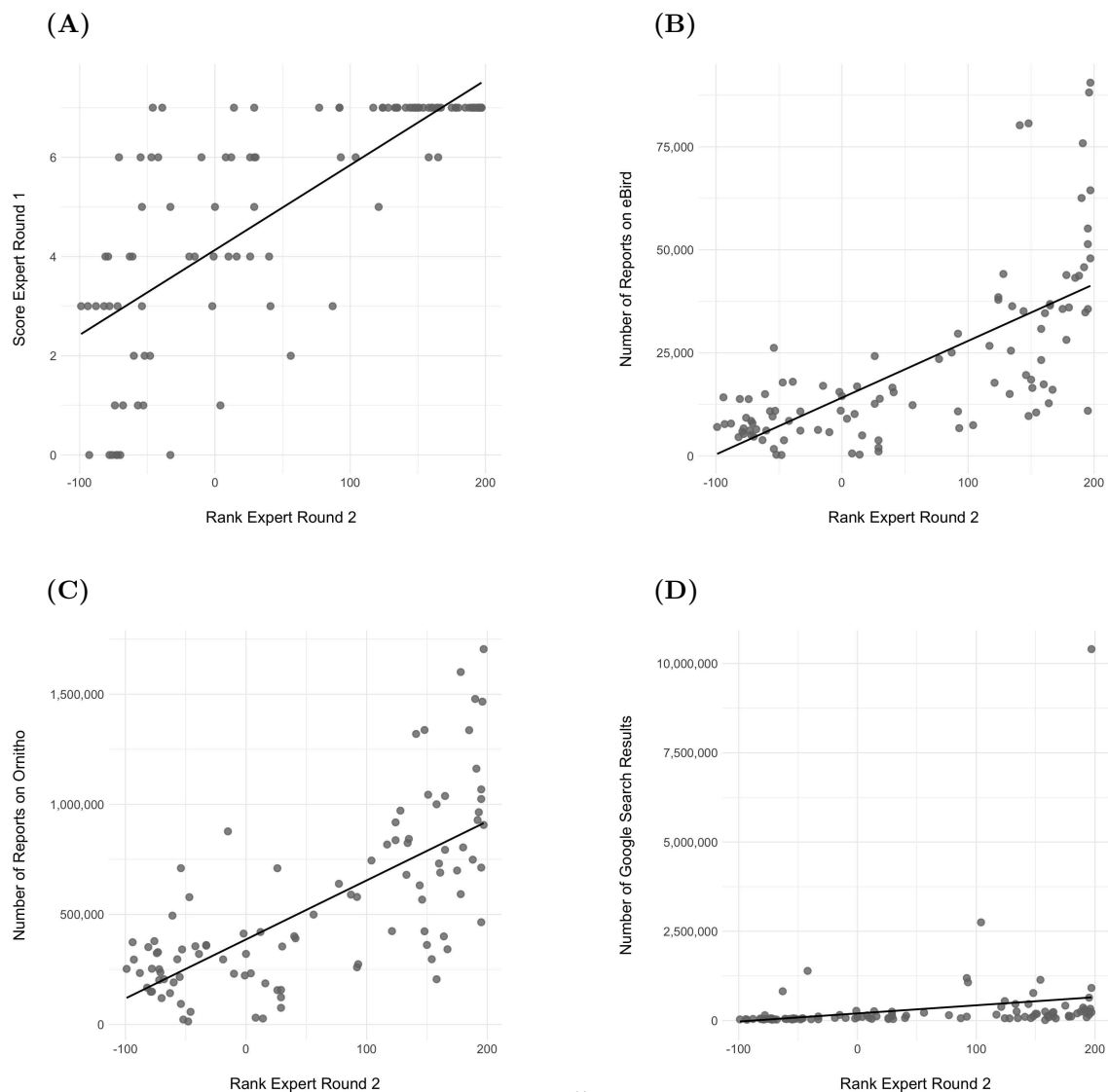


Figure 3.1.3: Correlations (Spearman-Rho) of Expert Round 2 with: (A) Expert Round 1; (B) Number of observations (of the respective species) reported on eBird; (C) Number of observations (of the respective species) reported on Ornitho; (D) Number of Google search results.

Discussion

In this study, we aimed to select species that serve as a baseline for knowledge about bird species in the general public, in particular the ‘golden 50’. However, our data allow any other numerical cut-off to adapt it to other studies and study aims. Further, the method depicted here can be used as a template and adapted for other taxa and biogeographical regions. The selection carried out in this study is the largest and most detailed decision-making process for a species selection to date. On the one hand, it refers to several databases and on the other, the expert survey is characterised by a very high number of participants, not only on a small group.

To achieve the goal of a species selection, we used a selection based on different criteria related to the bird species itself (e.g., abundance, presence in CS data, presence in literature) and two rounds of expert assessments. Through this three-step procedure, a species list was created that represents the bird diversity in Germany and can be used as a baseline for knowledge about species. This is of value for educational institutions and studies on knowledge about species to make them more comparable and to monitor changes in the future, comparable to bird populations monitoring. Most of these studies on knowledge aim to find out how knowledge about species can best be improved (Enzensberger et al., 2022; Randler & Heil, 2021). Since knowledge about species is an important basis for species conservation, the compiled list is a starting point for further research in this field. Other studies on knowledge about species have frequently used some of the above categories for their species selection as well. For example, Zahner et al. (2007) used NABU’s Garden Birdwatch to make a preselection for an expert panel. Consequently, garden birds were used in their study, as they were in Enzensberger et al. (2022) or Cox and Gaston (2015). Sturm et al. (2020) selected species for their knowledge study based on common species encountered in Berlin, while Prokop and Rodák (2009) used common species encountered in Slovakia. By using only isolated indicators or databases for species selection, bias in species selection can easily occur, as described in the introduction. Consequently, our species selection has the advantage of referring to multiple databases, not just garden bird counts or breeding bird data.

Nevertheless, our data analysis must also be viewed critically, as it also creates biases. As we wanted to represent bird diversity in the list, we compared the species per avian order of each selection with the number of species from the German avifauna (Barthel & Krüger, 2019). We found that the avian orders were equally represented as the chi-square tests were all non-significant. In addition to this advantage over other studies, the most important difference to the lists already compiled by other studies is that we referred to different databases such as CS data (Club 300, eBird, Ornitho, Garden Birdwatch (NABU)), the Bird of the Year election (NABU), scientific studies (previous studies on bird knowledge, Breeding Bird Census (ADEBAR)), and bird-related literature. Hence, we generated as many independent prioritisations as possible that provided information on how common and possibly known different bird species are.

The data analysis provided a good starting point for the expert panel in Step II. By comparing the two EFAs in Step II, it became clear that expert opinion is not essential to further reduce the species list. Nevertheless, in this study, we decided to consider the expert opinion from Step II to add a social dimension to the study to differ from species selections already carried out. Through the three-step process, an effortful but well-founded list of species was created, which can now be applied throughout Germany. Moreover, the procedure can also be transferred to other biogeographical regions, but according to our results, the involvement of (so many) experts would not be necessary. Still, to achieve a reference to society, it is worthwhile to consult experts.

To provide the experts in Step III with a selection of bird species, the first expert assessment list was set at 100 species, respectively (to include all orders or songbird families) at 102 species. The significantly high correlation between expert assessment 1 with expert assessment 2 shows that it was useful to include a small panel of experts to narrow down the initial selection from 185 to 102 species. However, this also means that our small group of ornithologically experienced people was sufficient to assess which species should be known. Whether expert groups consisting of a few people are suitable for species selection would have to be verified by repeating the process several times.

This means that for previous studies on knowledge about species, such as those by Zahner et al. (2007), which also involved a group of experts in the selection of species, a solid assessment of the test birds has probably already been made. As mentioned, however, selections were only made on the basis of garden birds. Furthermore, Jaun-Holderegger (2019) used a small group of experts (two zoologists) to decide the perceptibility and abundance of the species. Involving experts in the species selection is certainly the right approach but, based on our results, it is recommended to undertake a data analysis of different databases in advance.

The experts of Step III appear to be representative of the German population in terms of age and gender distribution, as the average age in Germany is currently 44.6 years (Rudnicka, 2022), and slightly more males than females pursue an ornithological leisure activity (Moore et al., 2008). In addition, the self-reported birding specialisation of the experts was, as expected, high. Almost three-quarters of the participants are active bird-watchers, so it would be expected that they would have a good knowledge of bird species. The participants covered a wide range of people involved with birds, both professionally and privately. This allowed the benefits of the wisdom of the crowd to be fully exploited (Krause et al., 2010). This is also shown by the results of the correlation of the second expert assessment with all the data included in this study. This includes the databases of the analysis in Step I, the expert assessment 1 (Step II) as well as colourfulness, body mass, and Google search results. According to this, experts are good at estimating abundance and familiarity and intuitively include these in their choices when it comes to selecting a baseline for knowledge about bird species. However, the experts did not seem to base this on the colourfulness of the species, suggesting that they rely more on abundance and

familiarity and do not prefer colourful species to dull species when asked this question. Because the subjective opinion of the experts was very much in line with the data analysis, the huge benefit of our expert assessments becomes visible: they allow us to strengthen the data analysis.

On average, the experts rated 57.88 species that should be known by the general public. This is close to the 50 species we had originally intended. The ‘golden 50’ list could be used as a guideline for future studies and adjustments are entirely possible if plausibly justified. Especially since past studies on knowledge about species used between 8 (Mmassy & Røskaft, 2013) and 28 (Randler & Heil, 2021) birds, but mostly between 12 and 16 (Dallimer et al., 2012; Enzensberger et al., 2022; Gerl et al., 2018; Sturm et al., 2020; Zahner et al., 2007), a reduction of the list for future studies on knowledge is worthwhile. The extent to which the species list is reduced then depends on the respective objective of the study. In this study, however, the list should not be reduced further, as it agrees with the number of species given by the experts. Comparing the ‘golden 50’ with the species lists of other studies, the used species are mostly included in our list. In the German studies by Sturm et al. (2020) and Gerl et al. (2018), only one species of each study is not included in our list (Hooded Crow (*Corvus cornix*) and Eurasian Siskin (*Spinus Spinus*)). However, all species of Randler and Heil (2021) are represented. With a few exceptions, the species used in other European studies are also listed in the ‘golden 50’. In the Swiss study by Jaun-Holderegger (2019), in the English study by Cox and Gaston (2015), and in the Dutch study by Hooykaas et al. (2019), one species, two species, and three species are not represented respectively. This is probably mainly due to the slightly different species compositions in the countries.

The ‘golden 50’ list contained one neozoon, the Canada Goose (*Branta canadensis*). This can be debated, as Canada Geese can have impacts on native bird populations (Kumschick & Nentwig, 2010). Nevertheless, the Canada Goose appeared in all our databases used for species selection and was supported by our experts. If the Canada Goose is included in the species list, a discussion about non-native species and their impacts on ecosystems can be stimulated in an educational context, for example, opening up a new subject to be addressed. However, it can be discussed whether the White-tailed Eagle should be included in the list or not, as this species received the most support from the experts. Therefore, we would also be satisfied with a species selection that omits the Canada Goose and includes the White-tailed Eagle instead.

Conclusion

With the list of the 'golden 50' (Table 3.1.3), our work shows which bird species could serve as a baseline for knowledge about species. This list is therefore a template for the selection of species in studies on knowledge about species and enables future scientists working on knowledge about species to make an informed choice of species for their study. In addition, the list can be used by educational institutions to determine which species should be taught. The list can also help to select so-called flagship species. This all supports the promotion of knowledge about species, which seems immensely important in the context of species extinction. The selection process can be used again in the same way, to select species for studies on knowledge, for example, in other biogeographical regions or other taxa.

3.2 Study II: Unlocking Biodiversity Awareness: Influential Factors on Bird Species Knowledge and the Links with Environmental Attitudes and Connectedness to Nature.

Abstract

In the face of accelerating biodiversity loss, there is a need for widespread public support for conservation efforts. To increase the understanding of biodiversity issues, researchers suggest beginning with the acquisition of species knowledge. However, to optimally support the successful acquisition of species knowledge, influencing factors must first be identified. Therefore, this study aimed to examine the relationship between species knowledge, environmental attitudes, and connection to nature, as well as individual variables such as interest, perception, and animal-related activities. Species knowledge was assessed using 50 bird species. A total of 3,438 German participants were asked to identify these species in an online survey. Structural equation modelling results indicated that interest in birds and involvement in animal-related activities positively influenced species knowledge. Surprisingly, the perception of birds negatively affected species knowledge, highlighting the complexity of personal biases in environmental education. While connectedness to nature doesn't directly influence bird knowledge, it emerges as a strong predictor of pro-environmental attitudes. Therefore, promoting species knowledge by stimulating interest and involvement in animal-related activities is essential for raising awareness of biodiversity conservation. Furthermore, connecting people with nature helps to foster pro-environmental attitudes, leading to a more sustainable and eco-centric future.

Keywords: bird species knowledge; 2-MEV-scale; environmental attitudes; interest in birds; animal-related activities; perception of birds

Introduction

The promotion of sustainable development, as outlined in the Sustainable Development Goals (UN, 2015), relies heavily on the conservation of biodiversity (Palmberg et al., 2017). Currently, the rate of species loss on Earth is unprecedented in human history (Díaz et al., 2019). Bird species are also affected by this decline and currently, 13.5% of bird species are threatened with global extinction (Lees et al., 2022). To address the alarming trend of species extinction, it is imperative to foster sustainable practices within our society (Amel et al., 2017).

To promote understanding of the natural world, species knowledge – the ability to identify species – is considered fundamental (e.g., Lindemann-Matthies & Bose, 2008; Randler, 2008b). Many scientists and conservationists see it as the starting point for creating awareness of nature and its biodiversity because it helps to understand the different roles of species in an ecosystem (e.g., Leather & Quicke, 2009). In addition, species knowledge provides a basis for understanding scientific discussions about biodiversity loss and broader environmental challenges (Jiwa & Esa, 2013). Accordingly, species knowledge is often thought to enhance pro-environmental attitudes, but research in this field is rare (Härtel, Randler, & Baur, 2023).

Pro-environmental attitudes play a crucial role for several reasons. For example, attitudes often shape behaviour (Laurie et al., 2016) and can contribute to shaping social norms (Chung & Rimal, 2016). This can contribute to a feedback loop in which sustainable behaviours become more socially accepted and adopted (Davis et al., 2018). In addition, individuals with pro-environmental attitudes are more likely to advocate for policies that stand for environmental conservation (Rohrschneider & Miles, 2015). They are also more receptive to environmental education, thus fostering a greater understanding of environmental challenges (Ajaps & McLellan, 2015).

Environmental attitudes are often measured using the 2-MEV⁷ scale developed by Bogner and Wilhelm (1996), which has been independently validated in different countries, samples, and age groups from adolescence to adulthood (e.g., Boeve-de Pauw, 2013; B. Johnson & Manoli, 2010; Milfont & Duckitt, 2004). The scale is based on the values of preservation and utilisation. These values reflect different attitudes towards the environment and are conceptualised within eco-centric and anthropocentric thinking, resulting in two worldviews. Eco-centric attitudes (preservation) are characterised by a worldview that emphasises living in harmony with nature. Anthropocentric attitudes (utilisation) reflect a worldview that supports the use and exploitation of natural resources for human benefit. The 2-MEV scale thus captures the different ways in which individuals perceive and interact with the environment (Bogner & Wiseman, 1999).

In previous research, birds were often used to measure species knowledge (e.g., Enzensberger et al., 2022). This is probably due to the rich but manageable number of species present in

⁷Two Major Environmental Values.

Europe and the favourable conditions for observation (birds are diurnal and highly visible) (Gerl et al., 2018). Further, the protection of bird species is of great relevance due to their significant effects on the Earth's ecosystems and the many ecosystem services they supply (Whelan et al., 2015). Because of their accessibility and abundance, birds are valuable subjects for monitoring programmes, helping to assess habitat quality and the effectiveness of conservation efforts (Sullivan et al., 2014). In environmental education, birds serve as charismatic ambassadors and flagship species for biodiversity. They captivate learners with their beauty, diversity, and ecological importance, while symbolising the wider conservation efforts needed to protect entire ecosystems (Lees et al., 2022). Previous studies on adult knowledge of bird species have reported identification rates of over 50% (Randler & Heil, 2021) or around 46% (Enzensberger et al., 2022). The identification rates for students are somewhat lower, ranging from 31% in the United Kingdom (Evans et al., 2006) to 35% in Germany (Gerl et al., 2018) and 39% in Slovakia (Prokop & Rodák, 2009). This means that part of the knowledge is acquired after school.

Besides species knowledge, another important aspect of enhancing pro-environmental attitudes may be people's connection with nature. In their review, Restall and Conrad (2015) revealed that feeling emotionally connected to nature strongly predicts having a positive attitude towards environmental protection. Today, human beings are becoming increasingly disconnected from nature, as part of a syndrome known as 'extinction of experience' (Miller, 2005).

To our knowledge, the relationship between connectedness to nature and species knowledge is still unclear. However, many studies show that experiencing nature promotes learning, such as species identification (reviewed by Kuo et al., 2019). In addition, Roczen et al. (2014) showed that environmental system knowledge, which includes species knowledge (Kai et al., 2014), is significantly correlated with connectedness to nature ($r = .12$). Whether connectedness to nature is a predictor of species knowledge and environmental attitudes is one research desideratum of the current study.

Another stimulus for knowledge acquisition is interest. If people are genuinely interested in a subject, such as bird species, they are more likely to actively seek out information about it (Harackiewicz et al., 2016). Recent studies have shown that individuals interested in bird species seem to be more familiar with them (e.g., Randler & Heil, 2021). Therefore, it can be hypothesised that interest in birds positively influences species knowledge, creating a one-way relationship where interest drives knowledge acquisition.

Furthermore, R. L. White et al. (2018) reported a positive relationship between the likeability of birds and the knowledge of schoolchildren. People who value birdwatching in their gardens are also more likely to create a suitable habitat for birds in their gardens (Goddard et al., 2013). Emotions influence learning (Li et al., 2020), and if someone has a positive perception of birds, this could be a predictor of a higher level of bird species knowledge.

Another aspect of promoting species knowledge is engagement in activities related to animals. Participation in such activities may be a predictor of species knowledge due to the immersive nature of hands-on experiences, direct interactions, and self-directed exploration, which deepen understanding and facilitate informal learning (Randler, 2010; Schwichow et al., 2016). Furthermore, engagement in animal-related activities, participation in bird-related citizen science, and increased bird-related knowledge are mutually linked and together contribute to conservation efforts (Randler, 2021b). Therefore, another aim is to investigate whether interest in birds, perceptions of birds (i.e. how much someone likes and values birds) and animal-related activities have an impact on adults' species knowledge.

The current study addresses several limitations of previous studies. First, the species selection for the study is based on a complex selection procedure including rounds of expert review (Härtel, Vanhöfen, & Randler, 2023). This elaborate selection of 50 species sets the study apart from previous studies that have only surveyed a subset of 10–15 garden birds (e.g., Enzensberger et al., 2022). Second, an in-depth literature review was conducted to identify possible determinants and outcomes of species knowledge. Third, the study has a unique feature due to the remarkably high number of investigated participants and is, to our knowledge, one of the largest studies of species knowledge in the world.

Research aim and hypotheses

The current study aims to investigate key antecedents and outcomes of species knowledge, addressing important limitations of previous studies. Specifically, it seeks to link species knowledge with environmental attitudes and connectedness to nature, as well as other variables such as individual interests, perceptions, and activities.

Based on the theoretical and empirical background, the following hypotheses were developed (Figure 3.2.1).

- H1: Interest in birds positively influences species knowledge.
- H2: The perception of birds positively influences species knowledge.
- H3: Engaging in animal-related activities positively influences species knowledge.
- H4: Connectedness to nature positively influences species knowledge.
- H5: Species knowledge positively influences preservation.
- H6: Species knowledge negatively influences utilisation.
- H7: Preservation and utilisation are negatively correlated.
- H8: Connectedness to nature positively influences preservation.

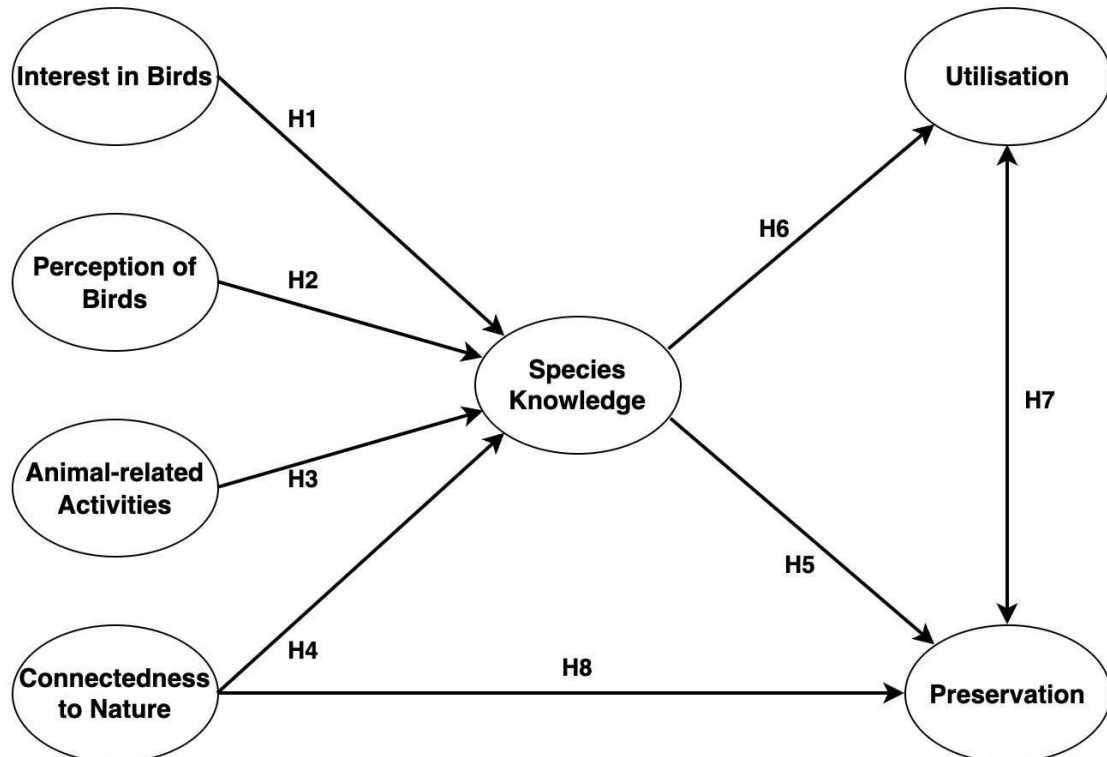


Figure 3.2.1: Hypothesised model of the relationships between species knowledge, its influential factors and preservation/utilisation. H1 to H8 correspond to the hypotheses formulated. Double-headed arrows indicate hypothesised bidirectional relationships between variables, single-headed arrows indicate hypothesised unidirectional relationships.

Methods

Survey

The investigated variables were assessed using an online questionnaire. The questionnaire was distributed throughout Germany from 25th October 2022 to 2nd June 2023. An access link was distributed via social media and the newsletter of various universities (Tübingen, Cologne, Bielefeld). Participants were additionally recruited via an online panel (WiSo Panel, wisopanel.net). A minimum age of 18 years was required for participation.

Demographic data

In total, 3,438 people took part in the study. The distribution of the respondent's demographic characteristics is shown in Table 3.2.1. More women than men participated in the study as well as a small number of diverse participants. The mean age of the respondents was 44.14 years ($SE = 0.29$ years), while most were 18–29 years and the fewest were 40–49 years old. Approximately one-third of the participants had an academic degree, while 19.4% had no academic degree and 49% did not answer the question. The survey was conducted throughout Germany. All postal codes whose first digit is a number from 1 to 9 were represented. Nearly one-third of the participants had a postal code beginning with

7, whereas participants with other first digits were evenly distributed. However, no people with postal code 0 took part in the survey. This applies to the federal states of Saxony, Brandenburg, Saxony-Anhalt, and Thuringia.

Table 3.2.1: Distribution of the respondent’s demographic characteristics (gender, age group, educational level, first digit of postal code).

	N	%
Gender		
Male	1301	37.8
Female	2059	59.9
Diverse	42	1.2
No statement	36	1.0
Age Groups		
18–29	938	27.3
30–39	536	15.6
40–49	501	14.6
50–59	631	18.4
60 or above	728	21.2
No statement	104	3.0
Educational level		
With academic degree	1085	31.6
No academic degree	666	19.4
No statement	1687	49.0
First digit of the postal code		
0	0	0.0
1	184	5.4
2	214	6.2
3	355	10.3
4	247	7.2
5	349	10.2
6	224	6.5
7	1050	30.5
8	211	6.1
9	275	8.0
No statement	329	9.6

Questionnaire design

The questionnaire consisted of three parts⁸. The first part of the questionnaire collected data on different demographic information, like age, gender, postal code, and education level. The second part included various questions in different answer formats, all taken from established reliable and valid scales. An overview of all variables and their respective items in the second part is given in Table 3.2.2. All items used were adopted from previous studies that have already implemented the items successfully (for references see Table 3.2.2). A visualised item and a scale consisting of 3 items were used for connectedness to nature. The third part consisted of 50 images of different bird species that are native to

⁸The questionnaire can be found in the Appendix (Study II - A1).

Germany. To determine which species should be used for a species knowledge baseline, species selection was carried out in three successive steps: an analysis of bird-related data and two expert assessments (for details see Härtel, Vanhöfen, & Randler, 2023). The participants were asked to write the species name under each bird image. Alternatively, it was also possible to tick that one cannot name the species. To clarify the classification of the species in the taxonomy, an example picture of a Red-crested Pochard (*Netta rufina*) was used. The order in which the bird images were displayed to the participants was randomised. This randomisation, together with the arrangement of the three parts of the questionnaire, ensures that a drop in motivation towards the end of the questionnaire does not affect overall performance in completing the items accurately.

Scoring of bird species knowledge

To assess species knowledge, we used partial credit coding. One point (1.0) was obtained for each correctly named species. Half a point (0.5) was given for naming the correct order, and in the case of songbirds, half a point (0.5) was given for naming the correct family. As many species have alternative names, these were also considered in the scoring.

Table 3.2.2: Means, standard errors, and measurement scales of the investigated variables and items.

Item	Item wording	<i>M</i>	<i>SE</i>	Measurement scale	Reference
Animal-related activity (AA)					
AA1	I go out into nature to observe animals.	3.04	0.02	5-point Likert (ranging from ‘never’ to ‘very often’)	Randler (2010); Cox and Gaston (2016)
AA2	I go to the zoo / Natural History Museum.	2.37	0.02		
AA3	I put up nesting boxes for birds.	2.36	0.02	Multiple Choice	
AA4	I feed birds in my garden / on my balcony.	2.51	0.02		
Interest in birds (IB)					
IB1	I am interested in ornithology / science of birds.	3.21	0.02	5-point Likert (ranging from ‘strongly disagree’ to ‘strongly agree’)	Randler and Heil (2021)
IB2	Birds are an important subject for me.	3.66	0.02		
IB3	Birds fascinate me.	3.79	0.02		
Perception of birds (PB)					
PB1	I value birds because they are pleasing to the eye.	4.17	0.02	5-point Likert (ranging from ‘strongly disagree’ to ‘strongly agree’)	Belaire et al. (2015)
PB2	I value birds because they have pleasant songs.	3.9	0.02		
PB3	I value birds because they make me feel better, physically, or mentally.	3.46	0.02		
Connectedness to nature (CTN)					
CTN1	Graphical visualisation	4.72	0.02	7 images of overlapping circles labelled ‘me’ and ‘nature’, illustrating 7 levels of connectedness (ranging from complete separation to complete integration)	Kleespies et al. (2021)
CTN2	I feel connected to nature when I watch birds in my garden.	4.15	0.02		
CTN3	When I can recognise a particular individual, I feel more connected to it.	3.31	0.02		
CTN4	I feel relaxed when I watch birds in my garden.	3.84	0.02		
Preservation (PRE)					
PRE1	I enjoy trips to the countryside – for example to forests or fields.	4.41	0.01	5-point Likert (ranging from ‘strongly disagree’ to ‘strongly agree’)	Barbosa et al. (2021)(Original: Bogner and Wiseman (1999))
PRE2	I would enjoy sitting at the edge of a pond watching nature.	3.92	0.02		
PRE3	I have a sense of well-being in the silence of nature.	4.43	0.01		
Utilisation (UTL)					
UTL1	Plants and animals exist primarily to be used by humans.	1.76	0.02	5-point Likert (ranging from ‘strongly disagree’ to ‘strongly agree’)	Barbosa et al. (2021)(Original: Bogner and Wiseman (1999))
UTL2	Mankind should rule over the rest of nature.	1.6	0.02		
UTL3	Human beings are more important than other creatures.	1.96	0.02		

Data analysis

To test the predicted hypotheses, a structural equation model (SEM) was calculated, using the R package lavaan (Rosseel, 2012). Structural equation modelling combines regression and confirmatory factor analysis (CFA) and considers the influence of interacting variables on theory-based hypotheses (Riha et al., 2021). Variables measured with a Likert scale were dealt as continuous variables according to Rhemtulla et al. (2012). As no multivariate normal distribution was given in the data set for the SEM, a robust maximum likelihood estimate by Yuan-Bentler was applied (MLR). Missing values in the dataset were handled by using full-information maximum likelihood (FIML) estimators. The item with the most missing values was the graphical visualisation of connectedness to nature (1.3%; Figure 3.2.2).

To implement the SEM, a two-step approach was used (Anderson & Gerbing, 1988). For this purpose, the measurement model for example, the interaction of the latent variables with the observed variables – was verified for its validity in the first step. Therefore, a CFA has been carried out. In the second step, the structural model – for example, the interaction between the latent variables based on the hypotheses – was tested (Kim et al., 2020). The following ranges were used for the Fit Indices to indicate a good model fit: goodness-of-fit index (GFI) > 0.9, comparative fit index (CFI) > 0.9, root mean square error of approximation ($RMSEA$) < 0.08, and standardised root mean squared residual ($SRMR$) < 0.08 (Hu & Bentler, 1999; Zinnbauer & Eberl, 2005).

The items of the species knowledge variable were split into parcels based on their factor loadings (items with the 10 highest loadings were assigned to the first parcel, etc.). This was done to reduce the number of observed variables of species knowledge, thereby reducing the complexity of the model and the likelihood of convergence problems in the analysis (Bandalos, 2002). According to Comrey and Lee (1992), the factor loadings of the species were all categorised between fair (≥ 0.45) and excellent (≥ 0.71). The species with the highest factor loading for species knowledge was the Barn Swallow (*Hirundo rustica*) with 0.785. This shows that species such as the Barn Swallow are well suited to measuring species knowledge.

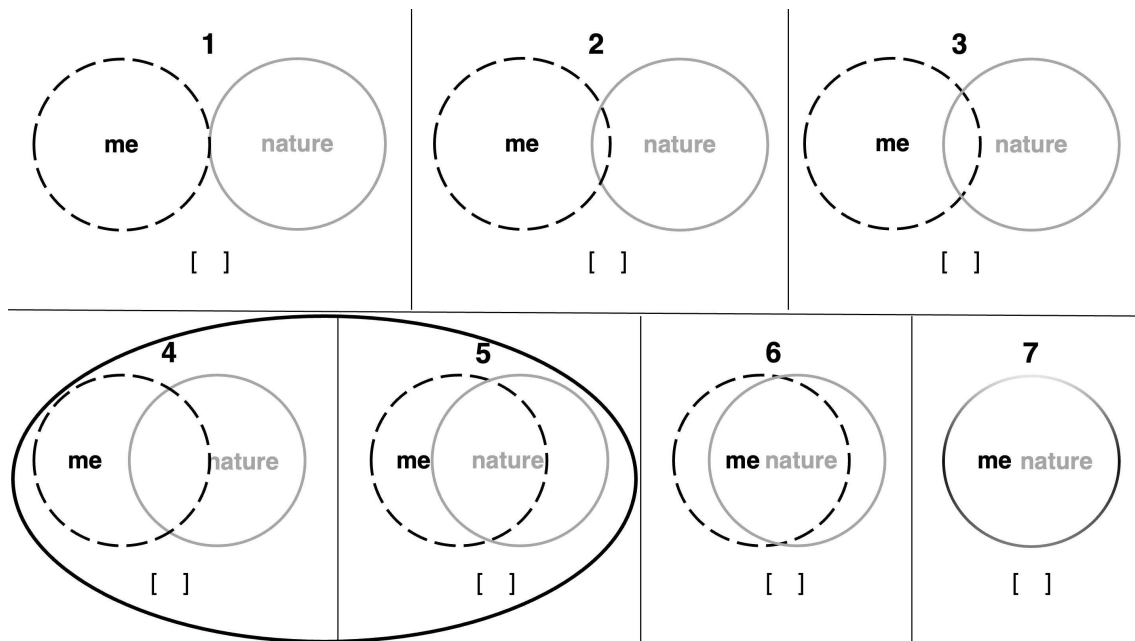


Figure 3.2.2: Graphical visualisation of the rating scale measuring connectedness to nature (CTN1). The participants were asked to tick the picture that most closely matches their connectedness to nature. As the mean value was between images 4 and 5 in the current study, they are circled in bold.

Results

Descriptive results

On average, participants achieved an identification score of 24.90 ($SE = 0.23$) out of 50 points. The minimum score was zero points while the maximum score was 50. That is, about 50% of the bird species were correctly identified at least at the family/order level. Mean values and standard errors of all items except the ones of the species knowledge items are shown in Table 3.2.2. Regarding animal-related activities, most people reported going into nature regularly to observe animals. This was followed by zoo/natural history museum visits and setting up nesting boxes. The frequency of bird feeding in the garden ranged on average between ‘irregularly’ to ‘regularly in winter’.

The participants were mainly interested in birds because they fascinated them. The item ‘I am interested in ornithology/science of birds’ received the least agreement compared to the other items on the interest scale.

Concerning the perception of birds, most people (82.4%) agreed (chose ‘agree’ and ‘strongly agree’) that they like birds because they are pleasing to the eye. The item that received the lowest level of agreement was ‘I value birds because they make me feel better, physically or mentally’.

Their connectedness to nature, which the participants were asked to depict through various images, was on average between images 4 and 5 with a tendency towards 5 (Figure 3.2.2). 81% of the participants agreed (chose ‘agree’ and ‘strongly agree’) that they feel connected to nature especially when watching garden birds.

Regarding preservation, the fact that one has a sense of well-being in the silence of nature received the highest level of agreement. This was also the highest-rated item compared to all other items on the questionnaire. The highest level of disagreement reached the item ‘Mankind should rule over the rest of the nature’, which is included in the utilisation scale. Figure 3.2.3 shows a boxplot of all variables. Preservation was the variable with the highest means ($M = 4.25$, $SE = 0.01$) compared with the other variables. Participants also like and value birds on a high level ($M = 3.84$, $SE = 0.86$), followed by their perceived connectedness to nature ($M = 3.7$, $SE = 0.01$), and their interest in birds ($M = 3.56$, $SE = 0.02$). The box of animal-related activities is partly and the box of utilisation was fully in the lower half of the x-axis (activities: $M = 2.76$, $SE = 0.02$; utilisation: $M = 1.78$, $SE = 0.01$). That is, the participants tend to engage in few such activities and anthropocentric attitudes (utilisation) are less prevalent.

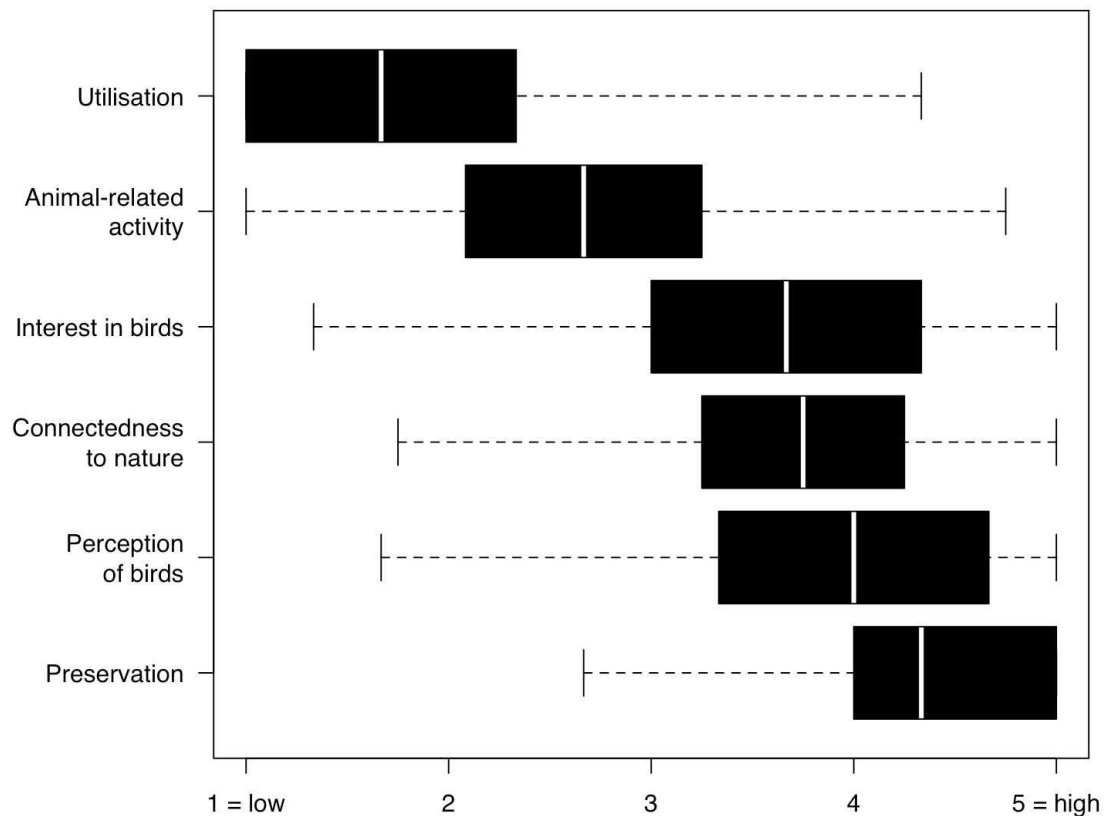


Figure 3.2.3: Boxplot of the following variables: Utilisation ($Md = 1.67$); Animal-related activities ($Md = 2.67$); Interest in birds ($Md = 3.67$); Connectedness to nature ($Md = 3.75$); Perception of birds ($Md = 4.00$); Preservation ($Md = 4.33$).

Measurement model

The validity of the observed variables in relation to the latent variables was tested in one measurement model by using CFA. The fit indices of the measurement model were 0.933 for *CFI*, 0.986 for *GFI*, 0.069 for *RMSEA*, and 0.046 for *SRMR*, indicating a good model fit (Hu & Bentler, 1999; Zinnbauer & Eberl, 2005).

Most Items/Item-Parcels were above 0.71 (Table 3.2.3), which means that the latent variable has more than 50% in common with the factor. According to Comrey and Lee (1992), this can be classified as ‘excellent’. Seven items had factor loadings below 0.71 but were still in the good (≥ 0.55) to very good (≥ 0.63) category. Nine items fell into the fair (≥ 0.45) to poor (≥ 0.32) category, but to have enough items per scale, we decided to keep them. Only item AA2 was dropped from further calculations due to its very poor factor loading of 0.27.

In addition, Cronbach’s α was calculated for each construct (Table 3.2.3) to confirm their reliability. According to Hinton et al. (2004), the coefficient of species knowledge indicates a very high internal consistency of the construct. Animal-related activities had a Cronbach’s α of 0.69, which can be interpreted as ‘moderate’. The alpha coefficients of the other constructs ranged from 0.77 (utilisation) to 0.89 (interest in birds), indicating a high internal consistency (Hinton et al., 2004).

Both, the fit indices, and the factor loadings, as well as the Cronbach’s α coefficient showed that the measurement model is well suited for developing the SEM in the next step.

Structural model

The structural model was calculated to address the hypotheses that have been proposed (Figure 3.2.1). The fit indices of the resulting SEM demonstrated a good fit with the data (*CFI* = 0.960, *GFI* = 0.995, *RMSEA* = 0.068, *SRMR* = 0.038). The overall model explains 41.3% of the variance in bird species knowledge. Furthermore, 47.5% of the variance in preservation as well as 6.8% in utilisation are explained by the SEM.

As hypothesised, interest in birds and animal-related activities can serve as a significant predictor of species knowledge (interest in birds: $\beta = 0.663$, $p < 0.001$; animal-related activities: $\beta = 0.116$, $p < 0.001$). The perception of birds significantly predicted species knowledge, but it is a negative relationship ($\beta = -0.123$, $p < 0.001$). No significant effect of connectedness to nature on species knowledge was found ($\beta = 0.029$, $p = 0.189$).

Species knowledge itself can serve to predict preservation on a significant level ($\beta = 0.177$, $p < 0.001$). This means that people with higher species knowledge also have more eco-centric attitudes. Moreover, species knowledge was negatively associated with utilisation, indicating lesser anthropocentric attitudes for people with higher species knowledge ($\beta = -0.260$, $p < 0.001$). A negative but significant correlation existed between utilisation and preservation ($r = -0.135$, $p < 0.001$). Connectedness to nature showed a positive significant effect on preservation ($\beta = 0.766$, $p < 0.001$). In Figure 3.2.4, all direct associations are displayed.

Table 3.2.3: Factor loadings, squared value/variance, and Cronbach's α of the items/scales.

Latent variable	Factor	Factor loading	Squared value/Variance	Cronbach's α
Species knowledge	SK1	0.95	0.89	0.96
	SK2	0.95	0.90	
	SK3	0.95	0.90	
	SK4	0.90	0.81	
	SK5	0.85	0.72	
Interest in birds	IB1	0.86	0.74	0.89
	IB2	0.88	0.77	
	IB3	0.83	0.69	
Perception of birds	PB1	0.73	0.53	0.79
	PB2	0.74	0.55	
	PB3	0.77	0.59	
Animal-related activities	AA1	0.76	0.57	0.69 (without Item AA2)
	AA2	0.27	0.07	
	AA3	0.58	0.33	
	AA4	0.55	0.30	
Connectedness to nature	CTN1	0.58	0.33	0.79
	CTN2	0.78	0.61	
	CTN3	0.68	0.46	
	CTN4	0.80	0.64	
Preservation	PRE1	0.79	0.63	0.79
	PRE2	0.72	0.51	
	PRE3	0.74	0.54	
Utilisation	UTL1	0.65	0.43	0.77
	UTL2	0.89	0.79	
	UTL3	0.66	0.43	

In summary, more animal-related activities and a higher interest in birds contribute to a higher bird species knowledge. Therefore, H1 and H2 can be accepted. However, H3 and H4 must be rejected because the perception of birds had a negative effect on bird species knowledge, and connectedness to nature had no significant effect. Bird species knowledge itself had, as predicted, a positive influence on preservation and a negative one on utilisation, implying H5 and H6 to be accepted. H7 can be accepted as well because of the significant negative correlation between preservation and utilisation. At last, H8 can also be confirmed due to the positive effect of connectedness to nature on bird species knowledge.

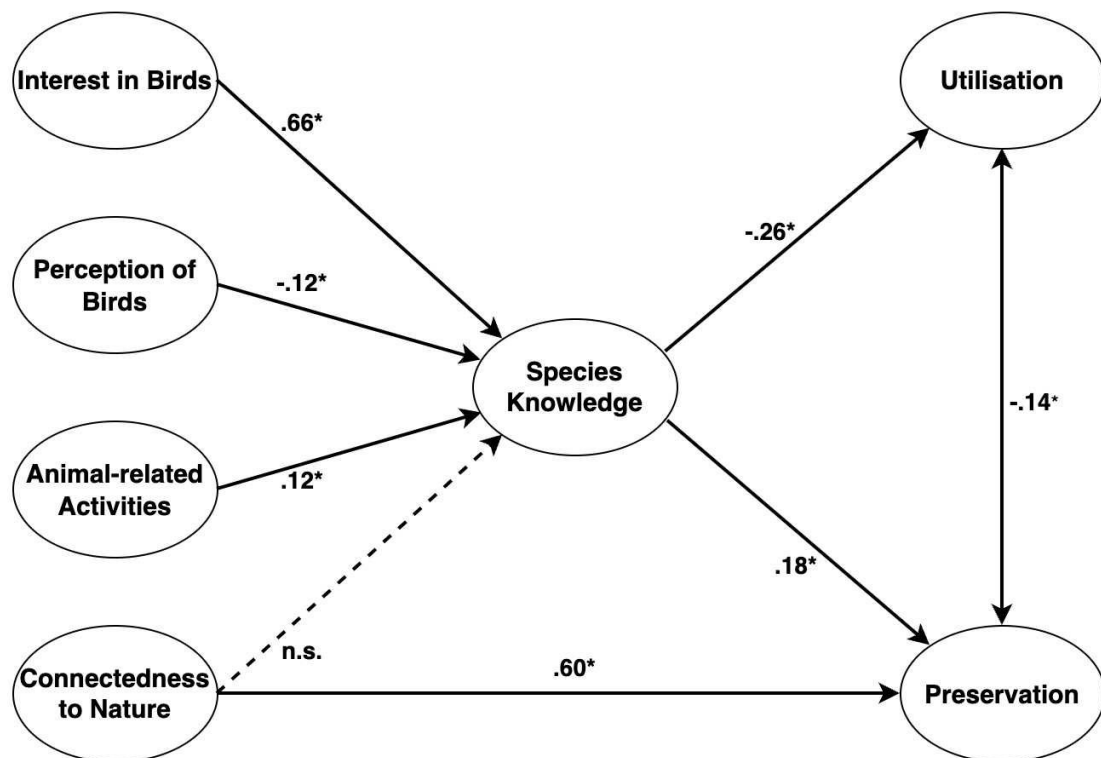


Figure 3.2.4: Structural equation model. Oval boxes represent latent variables. Numerical values indicate the standardised multiple regression coefficients (β) for one-sided or Pearson correlation coefficients (r) for reciprocal relationships. These coefficients describe the strength of the influence. Double-headed arrows indicate bidirectional relationships between latent variables, single-headed arrows indicate unidirectional relationships. Significant relationships are indicated by $*$.

Discussion

This study aimed to establish a link between species knowledge and environmental attitudes, as well as connectedness to nature, considering additional variables such as individual interests, perceptions, and activities. Here, we extended bird species knowledge research by using an SEM to estimate the direction and strength of various dependent variables. The knowledge score of around 50% is in line with previous research (Enzensberger et al., 2022; Randler & Heil, 2021), suggesting that participants' knowledge levels do not deviate significantly towards either low or high extremes. The model, based on hypotheses derived from theory and previous studies, fitted the data by identifying significant pathways, achieving good model fit and a satisfactory level of variance. In essence, the high levels of total variance in bird species knowledge and preservation of nature, indicating robust predictive power. However, the relatively low total variance in the utilisation of nature suggests that anthropocentric attitudes might be better explained by other variables, such as negative attitudes towards robots and positive associations with religiosity centrality and right-wing authoritarianism (Fortuna et al., 2023).

Interest in birds and animal-related activities can serve as a positive predictor of bird species knowledge, a relationship supported by findings from previous studies (e.g., Palmberg et al., 2015; Randler, 2010.). This underscores the importance of interest as a key predictor of species knowledge. This observation aligns with the concept of achievement emotions, especially interest, which refers to the emotional responses associated with achievement-related activities, such as studying, and the outcomes of these activities, encompassing both success and failure (Pekrun et al., 2002). The impact of interest in birds is further illuminated by its role in shaping the perceived importance and value of the subject matter, thereby influencing achievement emotions (Gläser-Zikuda et al., 2005). Individuals are more likely to invest effort in cognitive learning when they perceive the subject matter as interesting (Ainley et al., 2002). Consequently, environmental education could enhance species identification by introducing bird species that capture people's interest (Pany, 2014). Participation in animal-related activities, such as feeding birds in the garden, was also associated with higher species knowledge in previous studies (Cox & Gaston, 2015). By providing hands-on learning, participation in animal-related activities can improve a person's ability to identify species (Schwchow et al., 2016).

Surprisingly, the perception of birds had a significant negative effect on bird species knowledge, suggesting that personal experience may lead to cognitive biases or misconceptions that shape individuals' perceptions without necessarily increasing accurate species knowledge (Stammers, 2019). Furthermore, the findings of Cox and Gaston (2015) for non-songbirds, highlight that increased liking can paradoxically be associated with decreased species knowledge. Besides interest, further individual prepositions can affect knowledge about bird species and further investigated variables in the current study. Among professional birders, a study by Randler, Rahafar, and Großmann (2023) showed that skill/knowledge was negatively correlated with the Big Five personality trait of 'neuroticism'. Moreover, people with high levels of the Big Five personality trait 'agreeableness' show a higher positive affect towards emotions and moods, which is often seen as one quality of interest (Smillie et al., 2015). As a result, they are more likely to conform to social expectations and be more positive about certain issues, but this is independent of their actual knowledge (Sheese & Graziano, 2004). Future studies should investigate whether such personality traits influence the perception of birds. For example, individuals high in 'agreeableness' may exhibit high perception combined with low knowledge due to positive affect and conformity to social expectations (Smillie et al., 2015).

Connectedness to nature did not influence bird species knowledge, contrasting to the weak but significant correlation found by Roczen et al. (2014) between connectedness to nature and environmental knowledge. Individuals who enjoy activities such as walking or gardening may have a strong connection to nature, but this does not necessarily translate into learning about the specific species within these environments. Guided field trips are recommended to ensure effective learning as a way to feel connected to and experience nature (Jones & Washko, 2022).

Connectedness to nature was, on the other hand, a strong predictor of preservation, suggesting that individuals who feel strongly connected to nature tend to hold more eco-centric environmental attitudes. As reviewed by DeVille et al. (2021), many other studies point out this relationship. In fostering this connectedness, the importance of childhood exposure to nature is highlighted due to its role in shaping individuals' deep affinity for nature (Aziz & Said, 2012). In the current study, the median of connectedness to nature is in the upper third of the Likert scale (Figure 3.2.3), which means that the participants are characterised by a high level of nature connectedness per se. This observation is in line with a growing trend in recent studies, indicating a general tendency for the public to become more connected to nature (Oh et al., 2020).

Bird species knowledge emerged as a crucial factor in predicting environmental attitudes, particularly concerning preservation. (Härtel, Randler, & Baur, 2023) demonstrated a positive influence of species knowledge and students' environmental attitudes. Notably, this relationship also extends to adults, dispelling any speculation about a link between the two variables (Gerl et al., 2018; Leather & Quicke, 2009). Knowing bird species becomes a practical way to foster ecocentric attitudes, allowing individuals to actively contribute to biodiversity awareness and conservation (Hooykaas et al., 2019).

Consistent with other studies, preservation and utilisation were found to be correlated in the current study (Milfont & Duckitt, 2006; Nkaizirwa et al., 2022). The 2-MEV framework allows for an integrated set of values that may, but do not have to, include both preservation and utilisation of natural resources (Boeve-de Pauw & Van Petegem, 2013), emphasising that supporting preservation does not necessarily mean rejecting utilisation.

Limitations

However, it's important to note some limitations of our study. There may be a participation bias, as people who are involved in ornithological issues may be more willing to participate and may have a higher level of interest, for example, than others. As participation is voluntary, this bias is difficult to overcome. Furthermore, it is important to acknowledge potential limitations regarding the inferred causal relationships, although our computed SEM demonstrates robust predictive power. The identified and literature-based unidirectional pathways between variables suggest strong associations, but it cannot be excluded that bidirectional links or feedback loops may also exist within the system. Longitudinal studies over several years would be essential to establish causality conclusively. Such longitudinal research would provide deeper insights into the temporal dynamics of the relationships between variables, allowing for a more comprehensive understanding of the underlying mechanisms involved.

Conclusion

In summary, this study highlights the crucial role of bird species knowledge in shaping environmental attitudes, particularly towards the preservation of nature. We identified significant pathways, highlighting the positive influence of interest in birds and engagement in animal-related activities on species knowledge. This provides an important insight into how species knowledge can be promoted in the future. However, the unexpected negative effect of the perception of birds underscores the complexity of personal biases in environmental education. While connectedness to nature doesn't directly affect bird species knowledge, it emerges as a strong predictor of preservation, suggesting a link between the perceived connectedness to nature and ecocentric attitudes. In conclusion, promoting species knowledge is essential for raising awareness and sustainable development. It does not only enrich individuals' understanding of nature but also empowers them to actively contribute to biodiversity conservation, in line with efforts to achieve a more sustainable and eco-centric future.

3.3 Study III: Assessing Determinants and Trends in Bird Species Identification Skills Among Students: A Comparative Analysis with Early 2000s Data.

Abstract

The decline of Earth's biodiversity highlights the crucial role of knowledge about species in understanding ecological interdependencies and supporting conservation efforts. This study assessed bird species identification skills among 1,752 students (46.4% boys, 51.9% girls, 1.1% diverse) in grades 4–12 from different school types, focusing on 30 species. Demographic and individual factors were examined for their impact on bird species identification. Comparative analyses with a 2005 dataset reveal a significant 37.75% decrease in students' ability to correctly name birds at the species level. The average identification score was 6.84 ($SD = 4.10$) out of 30. Most students were only able to classify birds at the taxonomic level of family or order, but not at the species level. Factors such as age, school type, garden stay, distance to green space, interest in birds, perception of birds, and animal-related activities significantly influenced bird species identification. The study reveals a decline in bird species identification skills across all school types, particularly in schools of the highest stratification level, which nowadays have lower identification scores than medium stratification schools in 2005. The implications for educational institutions, particularly in the context of Education for Sustainable Development, emphasise the need for reevaluating curriculum and teaching methods.

Keywords: bird species identification; biology education; quantitative research; science communication

Introduction

The decrease in biodiversity is currently at an all-time high and the number of endangered species is increasing yearly (Leadley, 2010). This negatively impacts ecosystems and, in turn, ecosystem services. Ecosystem services like clean air or food production are important for humans. However, since ecosystems with lower biodiversity tend to be less stable, ecosystem services are also reduced (Cardinale et al., 2012). The causes of global biodiversity loss are complex, with land use, climate change, atmospheric CO₂ concentrations, nitrogen deposition and invasive species among the greatest threats (Leadley, 2010). Each of those is inevitably linked to human activities (Hooper et al., 2005). Understanding the underlying mechanisms that affect biodiversity and promoting sustainable decisions are crucial for future generations, aligning with the UN's⁹ Sustainable Development Goals. Target 4.7 emphasises the importance of education in fostering such sustainable development (UNESCO, 2021). Integral to this educational goal are species identification skills, which serve as a foundational element for comprehending biodiversity and ecological dynamics (Palmberg et al., 2017; Randler, 2008a). A solid understanding of common species and their roles within ecosystems is essential for individuals to effectively engage with environmental issues and understand the significance of conservation efforts (Bebbington, 2005). Integrating species identification skills into Education for Sustainable Development (ESD) is therefore essential, as it provides the necessary entry point for students to develop a deeper awareness and commitment to biodiversity conservation, ultimately supporting the wider aims of sustainable development (Navarro-perez & Tidball, 2012). However, it has recently been noted that citizens of Western societies often know little about native species (Almeida et al., 2018). This is worrying, as improved species identification skills are thought to be linked with more favourable attitudes towards wildlife and plants, as well as more positive attitudes towards the environment (Härtel et al., 2024; Härtel, Randler, & Baur, 2023; Orazem et al., 2021).

In the past, many studies on species identification used bird species in their assessments. This is probably due to the manageable number of bird species occurring in Europe and the good observability (Gerl et al., 2018). Birds are diurnal and easily visible, making them a common part of people's daily lives (Isaksson, 2018). Students have a genuine interest in animals and, because birds are so common, they are an excellent subject for excursions and environmental education activities (Drews, 2002). Furthermore, the conservation of bird species is of great importance, as they have a major impact on the Earth's ecosystems and provide several ecosystem services, such as nutrient cycling, seed dispersal, and many more (Hummel et al., 2015). In the context of ESD, birds can serve as flagship species, which are charismatic or iconic species selected to represent broader conservation efforts and biodiversity conservation goals (A. M. Smith & Sutton, 2008). Their beauty, diversity and ecological relevance capture the interest of learners and highlight the importance of wider

⁹United Nations.

conservation efforts (Lees et al., 2022). Additionally, skills in bird species identification are a good predictor of vertebrate and invertebrate species identification, according to a study by Härtel, Randler, and Baur (2023). The study was able to show that approximately 70% of the variance in species identification in general was explained by skills in bird species identification (Wilks- $\lambda = 0.84$), which is very high (Hair et al., 2013).

Literature review

The terms ‘species knowledge’ and ‘species identification’ are often used interchangeably to refer to the same concept (e.g., Gerl et al., 2021; Melis et al., 2021). In the literature, both concepts are primarily defined as the recognition and naming of species (Gerl et al., 2018; Randler, 2008a). However, some researchers extend the concept to a deeper knowledge of species, referred to as ‘species literacy’ (Hooykaas et al., 2019). Notably, species identification/knowledge has been shown to predict deeper knowledge about species (Hooykaas et al., 2022). In this study, we use the term ‘species identification’, defined as the recognition and correct naming of species, even if other studies use the term ‘species knowledge’ for the same concept. When referring to species identification in the context of birds, we will use ‘bird species identification’.

German school system

In Germany, the education system is stratified after grade 4 and is divided into different ‘levels’, with the Realschule being the medium and the Gymnasium being the highest stratification level. In the curricula of Baden-Württemberg (the federal state in which this study was conducted), zoological and botanical content is commonly integrated into biology education, especially in grades 5 and 6. In these early grades, basic concepts such as animal anatomy, behaviour and ecological interactions are emphasised. Later grades build on these foundations and include advanced topics such as human anatomy and physiology (MKJS BW, 2016a).

Current skills in bird species identification and change over the last decades

Some studies on bird species identification have been conducted in the past. Usually, the study designs differ in the number of bird species selected as well as in the species themselves. It is also noticeable that previous selections of species are often based on garden birds, rarely include winter visitors, and do not include nocturnal species (such as owls) or even neglect different avian orders. Table 3.3.1 shows the characteristics of bird species used in previous studies on students’ bird species identification.

However, it should be noted that today’s students usually correctly identify about one-third of bird species in identification tests (Gerl et al., 2021; Sturm et al., 2020). Nevertheless, many scientists suspect a decline (Atran et al., 2004). Due to differences in study design, it is difficult to determine whether and to what extent skills in bird species identification

have declined. Zahner et al. (2007) showed a loss of bird identification skills compared to the early 1980s (Eschenhagen, 1982) based on a sample of five bird species. For students at the Gymnasium in south-east Germany, a significant decrease in bird species identification skills could be shown (Gerl et al., 2018) and a 7% decline in bird species identification skills was observed among sixth graders from 2006 to 2018 (Gerl et al., 2021). However, these studies are based only on a small number of bird species, ranging from 5 to 12 species, which makes it important to study a reasonable number of bird species to achieve a sound result. The selection of bird species for such studies therefore needs to be based on a broad consensus. This has been developed by Härtel, Vanhöfen, and Randler (2023) and involves several steps, including database analysis and expert ratings.

Table 3.3.1: Previous studies about bird species identification in children and adolescents.

Study	Taxonomic representativeness (covering all avian orders)	Summer residents	Winter visitors	Circadian coverage	Spatial coverage	Local species
R. L. White et al. (2018)	no	yes	no	no	garden birds	yes
Härtel, Randler, and Baur (2023)	no	yes	no	no	mainly garden birds	yes
Schlegel et al. (2015)	no	yes	no	no	all birds	yes
Ortega-Lasuen et al. (2023)	no	yes	yes	no	all birds	yes
Gerl et al. (2018)	no	yes	yes	no	garden birds	yes
Gerl et al. (2021)	no	yes	no	yes	all birds	yes
Sturm et al. (2020)	no	yes	no	no	garden birds	yes
Zahner et al. (2007)	no	yes	no	no	garden birds	yes

Influence of demographics on bird species identification skills

Age is a determinant of bird species identification, but it's still unclear at what age species identification skills are highest. According to Zahner et al. (2007), skills in bird species identification of students increase with age. In contrast, a study by Randler (2008a) indicates that the identification rates increase until age 14 and then tends to regress. Other studies have identified peaks in bird species identification at ages 10, 15 and 19 (Gerl et al., 2018).

Studies also find inconsistent results when it comes to gender. Some studies show no gender differences (Cox & Gaston, 2015), sometimes boys perform better than girls (Huxham et al., 2006) and sometimes it is the other way round (Gerl et al., 2021).

The place of residence also seems to influence species identification skills. For example, rural residents are better at identifying plant and animal species than urban residents (Palmberg et al., 2015). However, a study in Puerto Rico found the opposite: urban dwellers were more knowledgeable about birds than rural dwellers (Vázquez-Plass & Wunderle Jr., 2010). Pitman and Daniels (2016) report that people with less exposure to nature have lower species identification skills. This is supported by Randler and Heil (2021), who found that the distance of residence from natural areas had a greater effect on skills in bird species identification than the urban-rural distinction itself (Randler & Heil, 2021).

Higher levels of education are often associated with higher rates of correct identification of bird species (e.g., Randler, 2010). However, Gerl et al. (2018) did not find significant differences in bird species identification skills between the different school types in Germany, possibly due to the low number of participants from medium-stratification schools ($N = 71$ vs. $N = 1,615$ from highest stratification schools).

Since all the previous work on demographic factors is so inconsistent, they still need to be considered for ongoing studies as basic determinants.

Influence of individual factors on bird species identification skills

The influence of individual factors on bird species identification is rarely assessed. However, studies investigating the relationship between environmental knowledge (of which bird species identification is a part (Kai et al., 2014)) and nature connectedness have concluded that they are only weakly related (e.g., Roczen et al., 2014). The emotional connection of humans to living animals and respectively to nature is understood as connectedness to nature (Mayer & Frantz, 2004). It is the motivational basis for nature conservation and sustainability (Barrable & Booth, 2020). Although a high level of species identification skills seem to increase appreciation of and attitudes towards animals (e.g., Melis et al., 2021), the extent to which nature connectedness applies to species identification skills has not yet been investigated in studies.

Interest in nature is positively related to the species identification skills of student teachers (Palmberg et al., 2015). Randler and Heil (2021) also showed that bird-related interest correlates with the bird species identification skills of adults. Furthermore, scientists, members of conservation societies, and bird owners have higher rates of bird identification and interest in birds than the general public (Prokop et al., 2015). However, Hummel et al. (2015) showed that students' bird identification skills did not determine their interest in birds. Since interest predicts knowledge acquisition (e.g., Rotgans & Schmidt, 2018), it is worth investigating whether interest in birds influences students' identification of bird species. To our knowledge, this has not yet been investigated.

Another individual factor that may impact bird identification skills is the perception of birds. The perception depends on the value we place on bird species, whether it is due to their pleasant songs, visual attractiveness, or the positive feelings they evoke. This perception fosters the reciprocal relationship known as human-nature interaction, which

influences the extent to which individuals support conservation efforts (Belaire et al., 2015). However, it remains unclear, whether the perception of birds has an impact on bird species identification. Cox and Gaston (2015) found that for songbirds, the likeability of a bird species is positively correlated with the correct naming of the species, whereas for non-songbirds, it was negatively correlated.

Individual differences in recreational activities may also influence species identification. For example, the frequency of engaging in animal-related activities correlates with insect and bird identification skills (Randler, 2010). These include, for example, observing animals in nature, and visiting museums or animal parks. In sum, studying individual factors to elucidate the determinants of species identification skills is mandatory.

Source of bird species identification skills

Parental guidance and the home environment emerge as primary sources for acquiring plant species identification skills, overshadowing the role of schools in this regard (Gatt et al., 2007). Yet, contrasting findings suggest that in some contexts, such as Finland, schools play a more prominent role in imparting animal species identification (Yli-Panula & Matikainen, 2014). This highlights the need for further research into the sources of species identification skill acquisition, particularly in the context of bird species.

Problem statement

We find ourselves at a crossroads, facing both a time of species extinction and dwindling human-nature interaction, resulting in a loss of knowledge about the natural world. This phenomenon, often referred to as ‘extinction of experience’ illustrates how reduced outdoor contact leads to reduced awareness and appreciation of biodiversity (Soga & Gaston, 2016). Because birds are a highly visible and widespread group of animals that play crucial roles in ecosystems, they serve as important indicators of environmental health. It becomes increasingly vital to gain a comprehensive understanding of the present state of bird species identification skills to pinpoint critical knowledge gaps. However, comparing identification rates over time is challenging due to differences in study design. Yet this is imperative for the evaluation of educational programmes. Understanding the determinants of bird species identification skills, such as demographics and individual factors, is also essential. This knowledge will enable educators and conservationists to tailor learning experiences, ultimately informing policy decisions, and fostering a more environmentally aware society.

Research questions

For the first time, at least to our knowledge, we have the opportunity to compare the bird species identification skills of today's students with that of students in the early 2000s. This opportunity is provided by a uniquely homogeneous study design that includes consistent species selection, study area, school types and criteria for defining bird species identification ('recognition and correct naming of bird species'). In addition, various demographic and individual factors were collected based on the following research questions:

1. Out of 30 common bird species, how many can students identify nowadays?
2. Which demographic and individual factors influence students' bird species identification skills?
3. What are the sources of students' acquisition of bird species identification skills? – which persons and what media are decisive?
4. How do the bird species identification skills of students today differ from those of students in 2005?

Methods

Research design

The survey took place in the state of Baden-Württemberg, using a paper-based questionnaire. Schools were selected to represent all regional councils, encompassing urban and rural settings.

Administered by the head researcher or trained students at the University of the authors, the study ensured a controlled environment. Eligible participants were from grade 4 onwards in primary schools and up to grade 12 in secondary schools. To compare bird species identification skills of today and the early 2000s, data from the current study were compared to a 2005 survey from Randler (2008a).

Participants

The 2022/2023 survey involved 1,752 students (46.4% boys, 51.9% girls, 1.1% diverse) aged 8–21 ($M = 13.1$, $SD = 2.58$). Participants included 12.3% from primary schools, 25.6% from medium stratification level, and 62% from the highest stratification level.

28 of 30 bird species from 2022/2023 survey were compared to a 2005 survey with 583 students (aged 9–19, $M = 12.88$, $SD = 2.39$). Similar to the 2022/2023 study, slightly more girls (59.7%) than boys (40.3%) participated in the 2005 study. 62.6% of the students went to school at the highest stratification level, 26.2% at the medium level, and 11.1% in primary school (Randler, 2008a). This distribution of students across different school

types is quite similar to that in 2022/2023. Additionally, as in 2022/2023, only schools from the federal state of Baden-Württemberg were surveyed.

Questionnaire design

The questionnaire consisted of four parts¹⁰. Part A asked the students' demographics, while Part B focused on individual factors, Part C asked about sources of bird species identification skills and Part D contained the bird species identification test.

Part A

Demographic data asked for were age in years and gender (male, female, diverse, prefer not to answer). In addition, two multiple-choice questions asking how often one spends time in the garden (garden stay; five response options ranging from daily to seldom) and how far away the nearest green space is that is regularly visited (distance to the next green space; four response options ranging from less than 1 km to more than 10 km).

Part B

An overview of all variables and their corresponding items of Part B is provided in Table 3.3.2. All items/scales have been adopted from previous studies (for References, see Table 3.3.2) and have been tested for reliability and validity.

Animal-related activities were measured with four items taken from different studies (Cox & Gaston, 2016; Randler, 2010). As the items came from different studies, an exploratory factor analysis (EFA) with principal component analysis (PCA) and varimax rotation of the four items was performed. The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.674, and Bartlett's test of Sphericity was significant ($p < 0.001$). This indicates a sufficiently high correlation between the items to run a PCA. Note that only factors with eigenvalues ≥ 1 were considered (Guttman, 1954; H. Kaiser, 1960). Examination of the Kaiser criterion and the scree-plot justified the extraction of a factor which explained a total variance of 49.93. As items 1–3 and 4 were scaled differently, a z-standardization was performed, followed by the calculation of the mean over the 4 items.

Part C

The students were also asked where they got their information about birds (source of species identification skills). A total of 8 choices were given in 2 categories (people and media) and students were asked to tick where applicable. The available choices were parents and grandparents, teachers, friends and acquaintances, informal teachers (people), as well as documentaries, the internet, books, and social media (media).

¹⁰The questionnaire can be found in the Appendix (Study III – A1).

Table 3.3.2: Overview of all scales of Part B of the Questionnaire. For each scale, the Item wording, Cronbach’s Alpha, Measurement Scale, and Reference are provided. Additionally, the mean and *SD* values that the students achieved are given for each scale.

Scale	Item wording	<i>M</i>	<i>SD</i>	Cronbach’s Alpha	Measurement Scale	Reference
Interest in Birds	I am interested in ornithology/science of birds. Birds are an important subject for me. Birds fascinate me.	3.01	0.98	0.86	5-point Likert (ranging from ‘strongly disagree’ to ‘strongly agree’)	Randler and Heil (2021)
Perception of Birds	I value birds because they are pleasing to the eye. I value birds because they have pleasant songs. I value birds because they make me feel better, physically, or mentally.	3.42	0.92	0.73	5-point Likert (ranging from ‘strongly disagree’ to ‘strongly agree’)	Belaire et al. (2015)
Connectedness to Nature	I feel connected to nature when I watch birds in my garden. When I can recognize a particular individual, I feel more connected to it. I feel relaxed when I watch birds in my garden.	3.04	1.00	0.81	5-point Likert (ranging from ‘strongly disagree’ to ‘strongly agree’)	Cox and Gaston (2016)
Connectedness to Nature (visualisation)	Graphical visualisation	4.53	1.39	–	7 images to choose from	Kleespies et al. (2021)
Animal-related Activities	I go out into nature to observe animals. I go to the zoo/Natural History Museum. I put up nesting boxes for birds. I feed birds in my garden/on my balcony.	2.40	0.85	0.66	5-point Likert (ranging from ‘never’ to ‘very often’) + Multiple Choice	Cox and Gaston (2016); Randler (2010)

Part D

To test bird species identification skills, the students were provided with 30 pictures of bird species that should and can be known in Germany. The species selection was based on the species selection of Randler (2008a) to ensure comparability and was supplemented by two additional orders based on the selection process of Härtel, Vanhöfen, and Randler (2023). These additional species were the Common Kingfisher (*Alcedo atthis*, order: *Coraciiformes*) and the Common Kestrel (*Falco tinnunculus*, order: *Falconiformes*).

The species selection in this study covers almost all bird orders, including summer and winter visitors, and owls for circadian coverage. In addition, not only garden birds but a wide range of local species are presented in the questionnaire, which distinguishes this study from others (see Table 3.3.1).

Students were asked to write the correct species name under each picture. A sample picture of the Red-crested Pochard (*Netta rufina*) was shown in the questionnaire to illustrate the taxonomic classification of a species.

Scoring the answers in the bird species identification test

Partial credit coding was used to assess bird species identification skills. One point (1.0) was granted for each correctly named species. For songbirds, half a point (0.5) was given for naming the correct family, and for non-songbirds, half a point (0.5) was given for naming the correct order. Alternative names that exist for different species were also considered in the scoring. The sum of the points was then calculated for each participant, resulting in the identification score. It should be noted that the identification score 2022/2023 was calculated from 30 bird species, but as soon as it comes to the comparison with 2005, from 28 species. In addition, the answer ‘stork’ was scored with one point in 2005. For the sake of comparability, this scoring was also applied to the data collected in 2022/2023 in the section ‘Comparative analysis of bird species identification skills (2005 vs. 2022/2023)’ (see Results). To assess construct variability and reliability of the identification score scale, we used a Generalised Partial Credit Model (GPCM), a polytomous Item Response Theory (IRT) model, as well as Construct Reliability (CR). The following ranges were used for the Fit Indices to indicate a good model fit of the GPCM: Tucker-Lewis Index (TLI) > 0.97 (Cai et al., 2023), Comparative Fit Index (CFI) > 0.95 (Bentler, 1990), and Root Mean Square Error of Approximation (RMSEA) < 0.05 (Maydeu-Olivares & Joe, 2014). Fit indices of the GPCM are shown in Table 3.3.3. Although the RMSEA of the 2005 model is > 0.05, these results collectively support the validity of the identification scores as an effective measure of bird species identification (Bentler, 1990; Cai et al., 2023; Maydeu-Olivares & Joe, 2014). Additionally, the CR values were 0.87 (2022/2023, 30 species), 0.86 (2022/2023, 28 species) and 0.82 (2005, 28 species), suggesting good convergent reliability (Hair et al., 2013).

Table 3.3.3: Fit indices of the Generalised Partial Credit Model (GPCM) for identification scores by survey year (2022/2023 vs. 2005) and number of species (28 vs. 30).

Model	χ^2 (df)	<i>p</i>	TLI	CFI	RMSEA, 90% CI
Identification score 2022/2023 (30 species)	633.0764 (405)	<0.001	0.991	0.992	0.018, [0.015, 0.021]
Identification score 2022/2023 (28 species)	551.4329 (350)	<0.001	0.991	0.992	0.018, [0.015, 0.021]
Identification score 2005 (28 species)	898.1453 (324)	<0.001	0.973	0.912	0.055, [0.051, 0.059]

Notes: χ^2 (df) = Chi-squares and degrees of freedom, *p* = *p*-value, TLI = Tucker-Lewis Index, CFI = Comparative Fit Index, RMSEA = Root Mean Square Error of Approximation, 90% CI = 90% Confidence Interval.

Statistical analysis

Cronbach's Alpha was used to measure the internal consistency of the different scales in Part B of the questionnaire. The internal consistency of the different scales of the questionnaire was moderate for and animal-related activities and high for interest in birds, perception of birds, connectedness to nature (see Table 3.3.2; Hinton et al., 2004).

Two (univariate) Generalised Linear Models (GLM) were calculated with the identification score as the dependent variable. To meet the prerequisites for calculating a GLM, the assumptions of normal distribution, homoscedasticity and the absence of multicollinearity between predictor variables were addressed. As the normal distribution was not met, a log-10 transformation of the identification score was performed. The normal distribution could then be confirmed graphically using a Quantile-Quantile-Plot. The test of homoscedasticity was carried out by graphical analysis of the residual plots of the variables. To check for multicollinearity between the predictor variables, the Variance Inflation Factors (VIF) were calculated. All VIF values were found to be < 2.6, indicating the absence of multicollinearity according to Daoud (2017). Initially, interactions between the factors were also included in the GLM. Non-significant interactions were then deleted and the GLM was recalculated. For post-hoc multiple comparisons, the Bonferroni correction was applied to the fixed factors of the GLM. Partial eta² was calculated to describe the effect sizes of the fixed factors and covariates in the GLM. Effects were interpreted based on Partial eta² values, with < 0.01 considered negligible, 0.01–0.06 as small, 0.06–0.14 as medium, and > 0.14 as large (Cohen, 1988). As only male and female were given as response options for gender in 2005, the diverse participants of 2022/2023 (*N* = 19) were not included in the part 'Comparative analysis of bird species identification skills (2005 vs. 2022/2023)'. A Student's t-test was calculated to compare the means of the identification scores in 2005 and 2022/2023. The significance level was set at *p* < 0.05. The programmes SPSS 28 and R were used for the statistics.

Results

Bird species identification skills today

The mean identification score achieved by the students was 6.84 ($SD = 4.09$). The minimum score was 0, and the maximum was 29.5. At the species level, students were able to identify 3.63 ($SD = 3.85$) bird species (12.96%), and including the family/order level, the total number of species identified was 10.05 ($SD = 4.57$) birds (33.5%).

Figure 3.3.1 shows the familiarity with the 30 bird species. Note that 89.6% were familiar with the Carrion Crow (*Corvus corone*) at least at the order level, but only 2.5% could name the species. The least known species name was the Common Chiffchaff (*Phylloscopus collybita*), which was identified by only 0.4% of respondents, all of whom were able to identify it at the species level. It is striking that the five best-known species names were mainly known at the order level, i.e. as ‘crow’, ‘owl’, ‘duck’, ‘stork’ and ‘pigeon’. Other species, such as the European Robin (*Erithacus rubecula*), if known, were mostly identified at the species level.

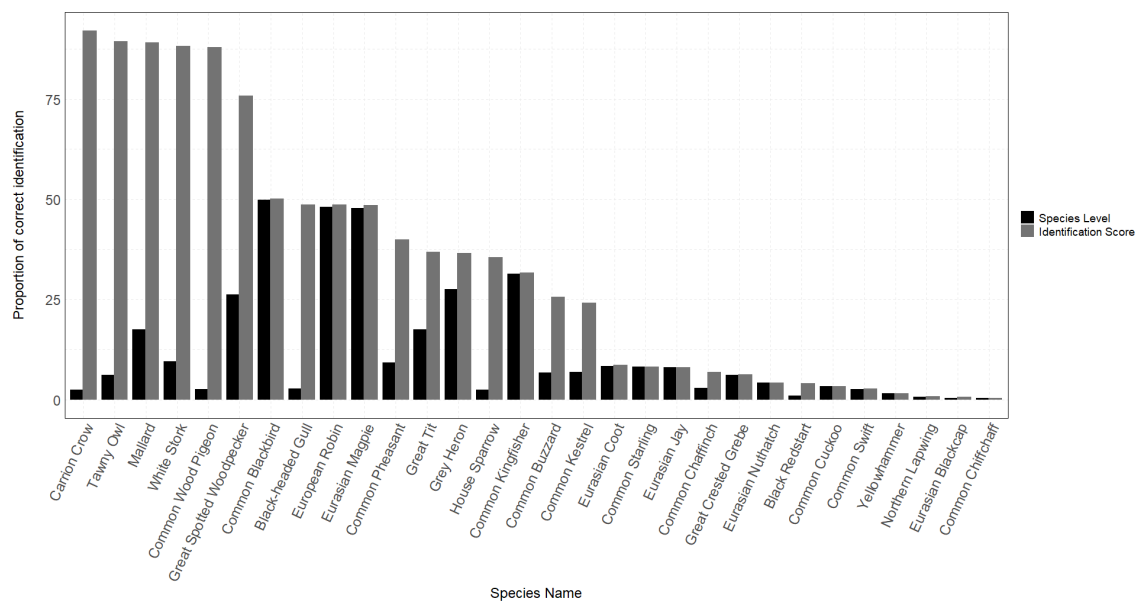


Figure 3.3.1: Proportion of correct identification of bird species in the 2022/2023 species knowledge test. It plots the familiarity with the species at least at the order or family level (=identification score, grey) and the familiarity at the species level (black).

Determinants of bird species identification skills

The mean and the SD values of the scales can be found in Table 3.3.2. As all interactions in the GLM with identification score as the dependent variable were non-significant (lowest p -value was $p = 0.158$ for school type*gender*distance to the next green space), the model was recalculated without these interactions. The overall model is shown in Table 3.3.4. The GLM was significant and the corrected R^2 was 0.308, which means that the model explains 30.8% of the variance in the identification score.

Table 3.3.4: Result of a GLM with bird identification score (log) as dependent variable (2022/2023 survey). Shown are the degrees of freedom (df), mean of squares, F -value, p -value, partial eta², and standardised regression coefficient (β) for each independent variable.

Source of variance	df	Mean of squares	F	p	Partial Eta ²	β
Corrected model	17	1.69	44.69	<.001	0.315	–
Constant	1	1.79	47.39	<.001	0.028	–
School type ^a	2	4.03	106.56	<.001	0.114	1 = 0.053 2 = 0.361
Gender ^b	2	0.23	6.03	0.002	0.007	1 = 0.070
Garden stay ^c	4	0.67	17.76	<.001	0.041	1 = –0.034 2 = –0.075 3 = –0.037 4 = –0.201
Distance to the next green space ^d	3	0.55	14.47	<.001	0.026	1 = –0.082 2 = –0.111 3 = –0.046
Age	1	1.76	46.52	<.001	0.027	0.175
Interest in birds	1	2.26	59.74	<.001	0.035	0.258
Perception of birds	1	0.52	13.72	<.001	0.008	–0.117
Connectedness to nature (visualisation)	1	0.01	0.09	0.769	0.000	0.008
Connectedness to nature	1	0.01	0.01	0.993	0.000	0
Animal-related activities	1	1.01	26.61	<.001	0.016	0.142

Notes: **Fixed factors:** school type, gender, garden stay, distance to the next green space.

Covariates: age, interest in birds, perception of birds, connectedness to nature (2x), animal-related activities. The fixed factors are coded as follows:

^a 0 = primary school, 1 = medium stratification level, 2 = highest stratification level

^b 0 = boy, 1 = girl

^c 0 = daily, 1 = several times a week, 2 = once a week, 3 = monthly, 4 = seldom

^d 0 = < 1 km, 1 = 1–2 km, 2 = 3–5 km, 3 = 6–10 km

Measured by the partial eta², school type was the most influential factor on the identification score with a medium effect size (Cohen, 1988). 11.4% of the variance in the identification score can be explained by school type. The post hoc analyses with Bonferroni correction showed that primary school and medium stratification levels, as well as medium stratification level and highest stratification level, differed significantly in the identification score ($p < 0.001$ in each case). Mean scores by school type were as follows: $M_{\text{primary school}} = 4.93$ ($SD = 3.43$); $M_{\text{medium stratification level}} = 5.07$ ($SD = 3.21$); and $M_{\text{highest stratification level}} = 7.95$ ($SD = 4.15$).

The frequency of garden stays significantly influenced students' identification scores with a small effect size (partial eta² = 0.041; Cohen, 1988). Those who seldom spend time in the garden had lower scores compared to monthly or more frequent stays ($p < 0.001$, see Figure 3.3.2). Moreover, a greater distance to green spaces was associated with lower

identification scores ($p < 0.001$). Identification scores were highest for those living less than 1 km away ($M = 7.24$, $SD = 4.11$) and decreased for those living 1–2 km away ($M = 5.77$, $SD = 4.00$), 3–5 km away ($M = 4.12$, $SD = 2.55$), and 6–10 km away ($M = 5.15$, $SD = 3.18$). However, the effect size was small (partial $\eta^2 = 0.026$; Cohen, 1988).

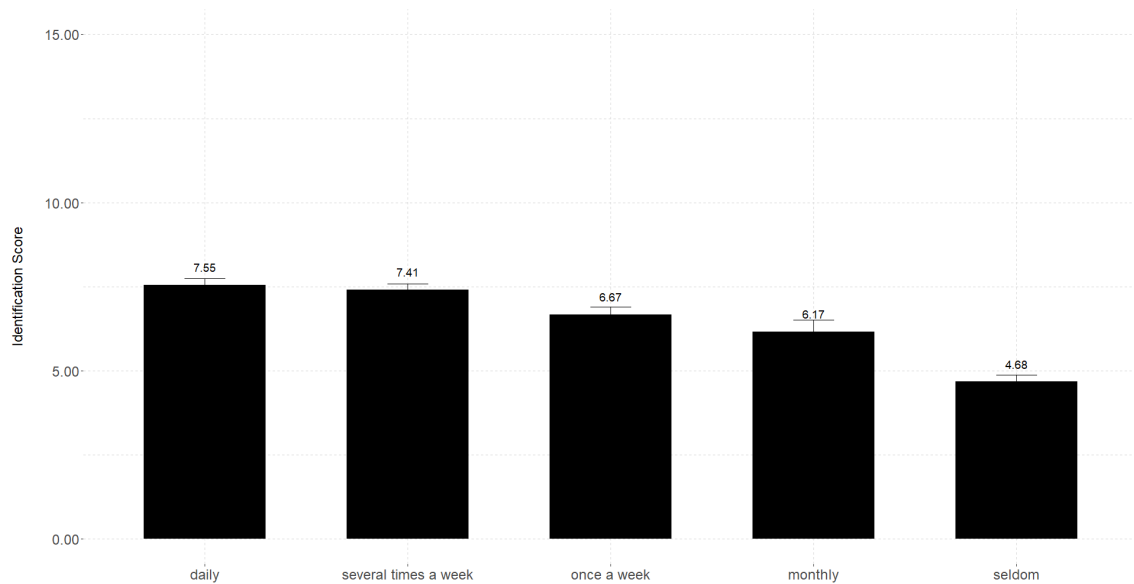


Figure 3.3.2: Mean bird identification score ($\pm SE$) depending on the frequency of garden stays in the 2022/2023 survey. The number of participants in each category was: daily ($N = 502$), several times a week ($N = 613$), once a week ($N = 246$), monthly ($N = 112$), seldom ($N = 265$).

Age also had a small but significant effect on the identification score ($p < 0.001$, partial $\eta^2 = 0.027$). In Figure 3.3.3, it is evident that skills in bird species identification appears to be highest at the age of 18. Initially, bird species identification skills increase until the age of 12, followed by a decline, after which identification skills gradually increase again. Gender had a significant impact on the identification score with women scoring higher than men ($p = 0.002$, partial $\eta^2 = 0.007$). However, since the partial η^2 was less than 0.01, this effect could be interpreted as negligible (Cohen, 1988).

Higher interest in birds and higher frequency of animal-related activities were associated with higher identification scores ($p < 0.001$ for both). Since the partial η^2 was 0.035 for interest in birds and 0.016 for animal-related activities, the effect size on the identification score was small (Cohen, 1988). Connectedness to nature does not have a significant effect on the identification score. A visualisation of the GLM is shown in Figure 3.3.4.

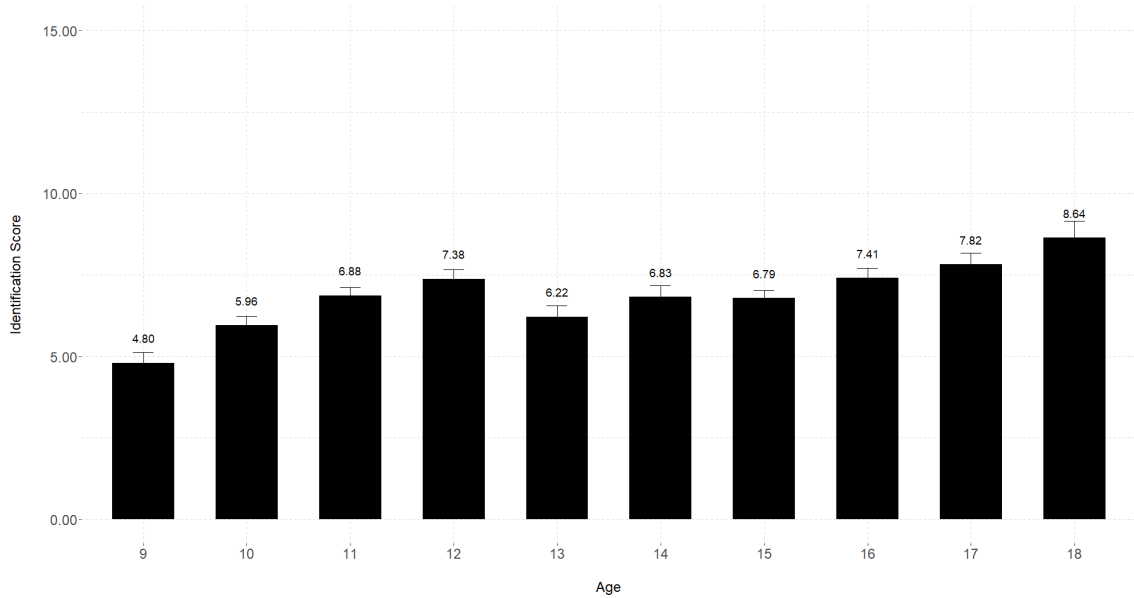


Figure 3.3.3: Mean bird identification score ($\pm SE$) according to age in the 2022/2023 survey. As the following age groups had only a few participants, these were removed from the graphic: 8 ($N = 2$), 19 ($N = 3$), 20 ($N = 1$), 21 ($N = 1$). The numbers of participants in the remaining age groups were: 9 ($N = 97$), 10 ($N = 216$), 11 ($N = 284$), 12 ($N = 254$), 13 ($N = 136$), 14 ($N = 150$), 15 ($N = 221$), 16 ($N = 183$), 17 ($N = 140$), 18 ($N = 61$).

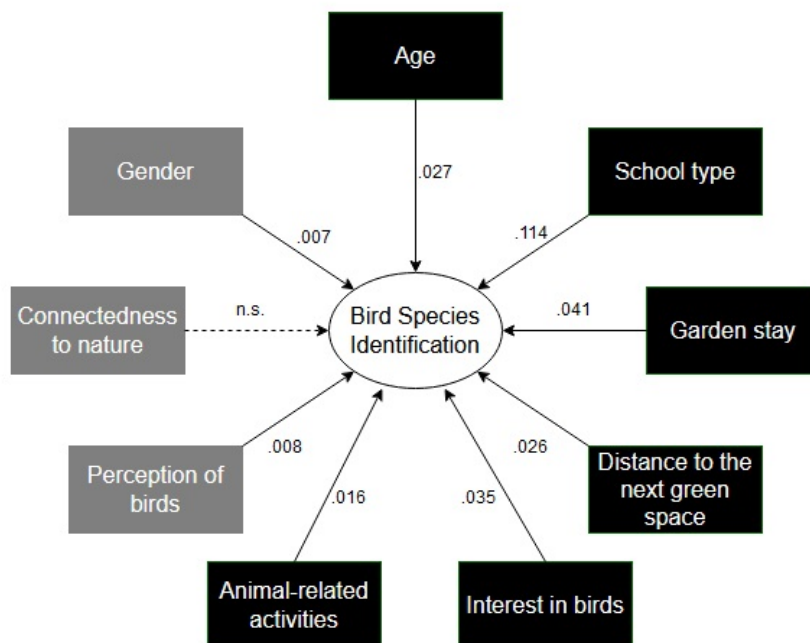


Figure 3.3.4: Influence of the different factors on bird species identification (resulting from the GLM) in the 2022/2023 survey. Black: positive effect, grey: non-significant (n.s.) or negligible effect (partial $\eta^2 < 0.01$). The number on the arrows corresponds to the partial η^2 . Solid arrows indicate significant effects, dashed arrows n.s.

Source of bird species identification skills

78.3% of students reported that they learned about species from their parents and grandparents (see Figure 3.3.5). This was followed by teachers, friends and acquaintances, and informal teachers (e.g., field trip leaders from nature conservation organisations, etc.). In terms of media, 66.0% said they learned about species from documentaries, followed by the internet, books and social media.

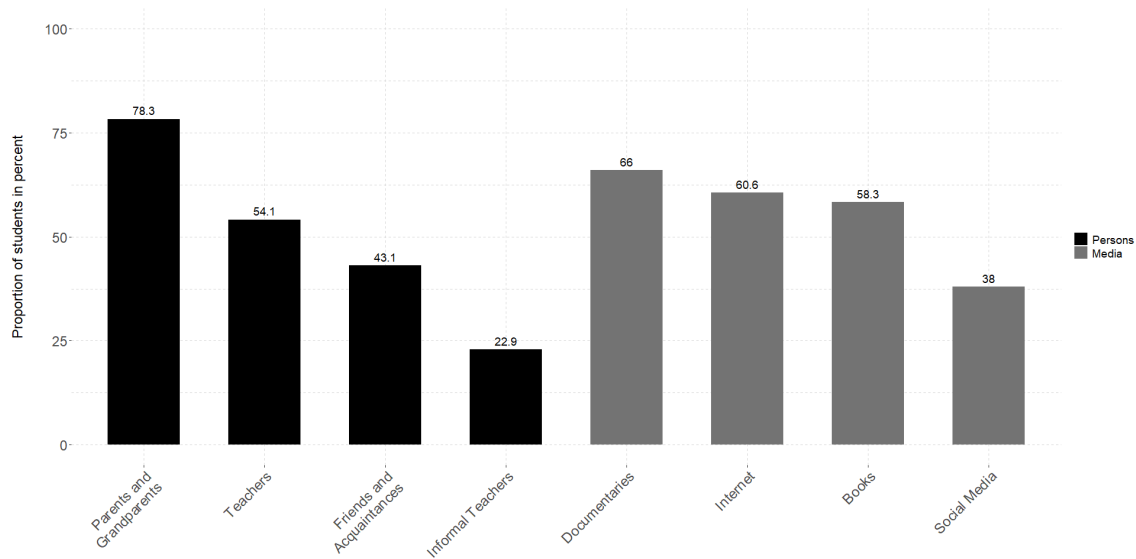


Figure 3.3.5: Source of the students' bird species identification skills in the 2022/2023 survey. Shown is the proportion of students who reported that they learned about a bird species from a person (black) or media (grey). Multiple answers were possible.

Comparative analysis of bird species identification skills (2005 vs. 2022/2023)

To compare the bird species identification skills the identification score was now calculated using only 28 species (which were surveyed in both 2005 and 2022/2023). At the species level, students were able to identify 6.46 ($SD = 3.65$) out of 28 species in 2005, but only 4.02 ($SD = 3.45$) in 2022/2023. Including the family/order level, 10.49 ($SD = 4.34$) species were correctly named in 2005 and 9.49 ($SD = 4.13$) in 2022/2023.

A GLM was calculated including data from both surveys. The effect of the independent variable survey year was calculated by controlling for the confounder's school type, gender and age on the dependent variable identification score. In the first GLM, all interactions between the factors were included, but subsequently, a second GLM was calculated without non-significant interactions (lowest p -value was $p = 0.264$ for survey year*school type*gender). The final GLM is presented in Table 3.3.5. The model was significant, explaining 16.7% of the variance in the overall mean identification score (corrected $R^2 = 0.167$). All factors except age had a significant effect on the identifica-

tion score. However, only school type had a medium effect size (partial $\eta^2 = 0.067$), while the effects of the other factors on bird species identification skills were small. The Bonferroni-corrected posthoc test showed a significant difference between all three school types ($p_{\text{primary school vs. medium stratification level}} < 0.001$; $p_{\text{primary school vs. highest stratification level}} < 0.001$; $p_{\text{medium stratification level vs. highest stratification level}} < 0.001$).

Table 3.3.5: Result of a GLM with bird identification score (log) as dependent variable (2005 and 2022/2023 survey). Shown are the degrees of freedom (df), mean of squares, F -value, p -value, partial η^2 , and standardised regression coefficient (β) for each independent variable.

Source of variance	df	Mean of Squares	F	p	Partial Eta ²	β
Corrected model	7	2.72	66.90	<.001	0.169	–
Constant	1	45.25	1112.56	<.001	0.326	–
Survey year ^a	1	2.03	50.00	<.001	0.021	1 = –0.064
School type ^b	2	3.34	82.14	<.001	0.067	1 = 0.984 2 = 0.853
Gender ^c	1	0.92	22.50	<.001	0.010	1 = 0.104
Age	1	0.04	1.08	0.298	0.000	0.012
Survey year*School type ^d	2	0.47	11.61	<.001	0.010	1*1 = –1.464 1*2 = –1.123

Notes: **Fixed factors:** survey year, school type, gender. **Covariate:** age. The fixed factors are coded as follows:

^a 0 = 2005, 1 = 2023.

^b 0 = primary school, 1 = medium stratification level, 2 = highest stratification level.

^c 0 = boy, 1 = girl.

^d 1*1 = 2022/2023*medium stratification level, 1*2 = 2022/2023*highest stratification level.

Table 3.3.6 shows the identification score for each type of school in the respective survey year. It is evident that the identification score has decreased for all three types of schools ($p < 0.001$, partial $\eta^2 = 0.01$). The current identification scores in primary and secondary schools are below the score of primary schools in 2005. The score of the highest stratification was below the score of medium stratification in 2005.

Table 3.3.6: Mean and SD values of the bird identification score depending on school type and survey year (2005 and 2022/2023 surveys).

School type	Mean 2005	SD 2005	Mean	SD
			2022/2023	2022/2023
Primary school	5.68	4.01	4.91	3.11
Medium stratification level	8.12	2.90	5.20	2.93
Highest stratification level	9.13	4.06	7.77	3.71

Overall, the identification score differed significantly between the two survey years ($p < 0.001$, partial $\eta^2 = 0.021$; $M_{2005} = 8.84$ ($SD = 3.93$); $M_{2022/2023} = 6.76$ ($SD = 3.69$)). Gender also had a significant influence on the identification score ($p < 0.001$, partial $\eta^2 = 0.01$), with girls having slightly better bird species identification skills than boys ($M_{\text{girls}} = 7.60$ ($SD = 3.68$); $M_{\text{boys}} = 6.78$ ($SD = 3.94$)).

Compared to 2005, bird species identification skills have decreased by 37.75% on the species level and by 9.53% overall (including family/order level). The difference in identification score between 2005 and 2022/2023 was significant at both the species level ($t_{(2335)} = 14.565$, $p < 0.001$) and the order/family level ($t_{(2335)} = 4.984$, $p < 0.001$).

Discussion

In the following, the results will be discussed under the research questions to which they relate.

Out of 30 common bird species, how many can students identify nowadays?

Compared to other recent studies, the bird species identification skills in the study at hand are very low. For instance, Zahner et al. (2007) reported a bird identification score of 35% in the German federal state of Bavaria, while Gerl et al. (2018) found that participants knew about one-third of the species in a second Bavarian study. High school students in the US also correctly identified 35% of birds in a knowledge test (Egger et al., 2024); Prokop and Rodák (2009) reported a 39% identification rate in Slovakia, and Evans et al. (2006) documented a 31% rate in the UK. In this study, students had an identification score of 22.8%, which was lower than expected based on the results of other studies. They were able to identify about 12% out of 30 bird species at the species level and about one-third at the order/family level. Most species were only known at a higher taxonomic level (family/order). This may be because taxonomy is rarely taught in German schools, and it can be assumed that students thought they had adequately identified the animal by giving the order or family (Gerl et al., 2021).

Which demographic and individual factors influence students' bird species identification skills?

The following will discuss the influence of demographic and individual factors on bird species identification, organised by their effect size in descending order.

In our study, school type had the largest effect on bird species identification, although the effect was medium. This finding indicates that students at higher stratification levels have higher identification skills. Additionally, those in the medium stratification level demonstrated limited improvement in bird species identification skills beyond primary school. Hence, educational level emerged as the predominant factor influencing bird species iden-

tification skills, potentially linked to cognitive abilities and memory capacity (Randler, 2008a). Discrepancies in curriculum content between medium and highest stratification levels during primary education were insufficient to explain the observed differences in identification scores. The disparity may stem from increased exposure to nature-related extracurricular activities or access to knowledgeable family members among students in the highest stratification level (Chevalier et al., 2013; T. H. White, 1975).

The remaining variables had a small but significant effect on bird species identification. Our findings indicate a direct relationship between students' time spent in the garden and their bird species identification skills. Research suggests that direct exposure to nature enhances biological understanding with outdoor experiences fostering memory formation and learning through various interactions (Longbottom & Slaughter, 2016). After school type and time spent in the garden, interest in bird species had the third largest effect on bird species identification. This is in line with previous studies conducted with student teachers (Palmberg et al., 2015) and adults (Randler & Heil, 2021). Interest has been identified as a powerful determinant of knowledge in science education since the 1990s (e.g., Gläser-Zikuda et al., 2005) because interest awakens the desire to learn more (Kleespies et al., 2021). Furthermore, the results of this study can be extended to recent findings highlighting the link between interest in nature and engagement in pro-environmental activities among adolescents (Neurohr et al., 2023). These findings underscore the broader findings of promoting interest in birds, not only for bird species identification skills but also for promoting environmental engagement.

Age significantly impacted bird species identification skills, showing a peak at 12 years old, likely due to zoological content taught in grades 5/6 in Germany. The subsequent decline during middle school years may reflect reduced biological interest typical of puberty (Bebbington, 2005). However, identification skills steadily increased until graduation, consistent with lifelong learning patterns observed in adults, likely due to increased learning opportunities with age (Randler & Heil, 2021). Additionally, distance to the nearest green spaces significantly impacts bird species identification, supported by Randler and Heil (2021). Increased exposure to nature explains this relationship, similar to time spent in the garden. The slight increase in identification skills between 3-5 km and 6-10 km distances may be due to the smaller sample size in the latter category ($N = 30$). Animal-related activities, such as observing animals in the wild, visiting zoos and museums, putting up nesting boxes and/or feeding birds, have a positive impact on bird species identification. This is consistent with recent studies. For instance, Randler (2010) showed that animal-related leisure activities of adults are positively related to the identification of animal species. Furthermore, regular bird feeding, a common practice in many gardens, is associated with higher skills in bird species identification by providing valuable opportunities for bird observation (Cox & Gaston, 2016; R. L. White et al., 2018). By providing a first-hand experience of nature, animal-related activities further emphasise the role of informal learning in knowledge acquisition (Kuo et al., 2019). However, it is important to note that

bird feeding offers benefits such as faster feather growth and reduced stress for birds, but it also has drawbacks, including an increased risk of infectious diseases (Wilcoxon et al., 2015).

Gender had a negligible effect on students' bird species identification. Given the inconsistent results of recent studies (e.g., Gerl et al., 2021; Hooykaas et al., 2019), gender does not appear to influence differences in bird species identification skills. Surprisingly, the perception of birds had a negligible effect on bird species identification. Contrary to expectations, the extent to which students like and value birds does not seem to influence their bird species identification skills. This may be attributed to cognitive biases or misconceptions arising from limited exposure or personal experiences (Stammers, 2019). Such biases can influence perceptions of birds without necessarily enhancing skills in bird species identification. Neither the connectedness to nature scale nor the visualisation item had a significant effect on bird species identification. As environmental knowledge itself is only weakly correlated with connectedness to nature, it seems unsurprising that skills in bird species identification are not influenced by it. Instead, species identification skills seem to positively influence attitudes towards animals (e.g., Melis et al., 2021). Testing this in relation to birds would be an approach for further research.

What are the sources of students' acquisition of bird species identification skills? – which persons and what media are decisive?

The predominant source of skills in bird species identification among students are parents or grandparents, aligning with previous research (Gatt et al., 2007). This is in line with research by Tunnicliffe and Reiss (2000), suggesting that the home is the most important place for children to learn about species. Documentaries were reported as influential as well, with two-thirds of students citing them as a source. The rise of nature documentaries on streaming platforms like Netflix and Amazon may contribute to their popularity (Aitchison et al., 2021). Books, once an important medium for species identification (Randler, 2010), rank third but they still outrank social media. Notably, students using identification apps for species identification performed similarly to those using books, but book users felt more competent afterward (Vanhöfen et al., 2023). Even if teachers are outranked by parents or grandparents, they remain crucial for acquisition of bird species identification skills, as over half of respondents cited teachers as contributors to their skills. When combined with digital media, such as bird identification apps, the effectiveness of species identification teaching practices could be significantly enhanced.

How do the bird species identification skills of students today differ from those of students in 2005?

In the GLM including data from 2005, age no longer has a significant effect on bird species identification. This change is likely because a peak in bird species identification skills was observed in 2005 at age 14 (Randler, 2008a), which differs by 2 years from the peak in the 2022/2023 data.

Comparing identification scores across different school types and survey years reveals a significant decline in bird species identification skills. The highest stratification level's identification scores now match the medium level in 2005, with primary and medium levels showing lower identification scores than in 2005. This shift may be attributed to two main factors: the removal of a mandatory teacher recommendation for secondary school placement in 2012 and the phased elimination of the lowest stratification level starting in 2016. However, the decline in bird species identification skills isn't solely due to school changes; identification skills has decreased by almost 38% at the species level and nearly 10% overall over 18 years. This means that students today can name far fewer bird species by their actual names than they could 18 years ago. While an increase in knowledge may not always translate directly into behavioural changes (Bandura, 1986), species identification skills serve as a crucial foundation for comprehending biodiversity and ecological dynamics (Randler, 2008a). This understanding is essential for effective nature conservation efforts (Palmberg et al., 2015). Therefore, promoting species identification skills aligns with the principles of ESD, which are in harmony with SDG 4.7 (Bebbington, 2005).

Declines in bird species identification skills among adults (e.g., Enzensberger et al., 2022) and a reduction in taxonomists (Frobel & Schlumprecht, 2016) further compound concerns, contributing to the shifting baseline syndrome, hindering effective conservation efforts due to a lack of awareness about the original, healthy state of ecosystems. Shifting baseline syndrome refers to the phenomenon whereby each generation sees the environment in which they grew up as normal, and therefore fails to recognise the extent of environmental degradation over time, leading to lowered expectations for ecosystem health and biodiversity (Soga & Gaston, 2016).

Limitations

Although this study represents a pioneering effort to compare skills in bird species identification across two survey years, several limitations must be mentioned. First, the 2022/2023 questionnaire was longer due to the inclusion of individual factors. Despite efforts to mitigate this by providing sufficient time and reminders to complete each item, fatigue may have affected response accuracy. Second, although the explained variance of 30.5% in bird species identification is relatively high for social science studies, there are unmeasured variables influencing skills in bird species identification. Third, the effect sizes of some of the variables examined were found to be small, so the results should be interpreted with caution. Fourth, this study only indicates a decline in identification skills of bird species in the federal state of Baden-Württemberg, Germany. Further research should therefore be undertaken to assess changes in bird species identification skills on an international scale and focus on more individual factors that may influence it. It would also be interesting to complement this quantitative research with qualitative methods to explore students'

broader knowledge of bird species. Understanding their prior knowledge could be crucial for planning effective species identification lessons.

Implications for educational institutions

Although the results of this study are specific to Germany, and particularly the federal state of Baden-Württemberg, they are of considerable international relevance. The recommendations derived from this research will be valuable for science education in schools worldwide, as a decline in species identification skills is suspected in other countries (e.g., Löbl et al., 2023; Papworth et al., 2009). Firstly, there is a need for a comprehensive species identification curriculum, particularly at the secondary school stratification level, to address potential disparities stemming from varying levels of parental involvement and informal education among students. It would be important to focus not only on botanical/zoological content in the lower grades but also in higher grades. Establishing and maintaining school gardens, complete with feeders and nest boxes, can serve as effective hands-on learning platforms, fostering curiosity and deeper engagement with bird species (Gurel, 2016; Jose et al., 2017). Educational strategies should aim to spark students' interest in birds, utilising methods such as field trips, integration of educational apps, and online resources (Marcal et al., 2017). Furthermore, participation in citizen science initiatives, including public bird counting events, holds promise for increasing both interest and identification skills of bird species among students (Bela et al., 2016). In addition, these approaches can mitigate loss of experience by reconnecting students with nature and fostering a deeper appreciation of biodiversity (Schuttler et al., 2018).

Conclusion

In conclusion, this comprehensive study sheds light on the current skills in bird species identification among students, revealing concerning trends. The overall bird species identification skills have significantly declined over the past 18 years, with a substantial drop in the ability to identify species by their specific species names. This study is the first to address this knowledge gap. Unlike previous research, it employs a rigorous species selection process, assesses many species, and crucially, utilises the same identification test to measure bird species identification skills in both 2005 and 2022/2023. The sample size is very high, and we can assume that the decrease in identification skills is real. The findings support concerns about reduced human-nature interaction leading to diminished knowledge. They underscore the importance of familiarising students with local species, especially in the context of declining taxonomic knowledge and biodiversity loss. The study thus contributes to ESD, which aims for science education to equip students with the knowledge and skills necessary to address environmental challenges. Inclusion of improved species identification skills in the curriculum would be an important first step.

4 General Discussion

This general discussion aims to unify the findings of the three studies and provide a cohesive narrative that highlights their relevance to species knowledge research and its practical applications in education and conservation. Based on a thorough species selection process, which is discussed first, this work provides a comprehensive perspective on the factors influencing bird species knowledge, its decline to date and its impact on environmental attitudes. The general discussion is rounded off by the subsequent chapters on limitations and implications.

4.0 ‘Golden 50’ Species Selection

As outlined in Chapter 1.2, the lack of a standardised baseline for the selection of bird species in knowledge surveys is a major challenge. Previous studies have varied widely in both the number and types of species included (e.g., Ehlers Smith et al., 2021; Randler & Heil, 2021), making it difficult to compare results between studies and to monitor changes in species knowledge over time. This lack of standardisation has been particularly problematic in demonstrating the perceived decline in species knowledge, an issue widely debated in conservation circles (e.g., Genschel, 1950; Frobel & Schlumprecht, 2016).

Without a consensus on which bird species to include, or the criteria for their selection, surveys risk introducing bias and inconsistency. Many previous studies have relied on only one or two criteria for species selection (see Table 1.2.1), which often leads to limitations. For example, focusing solely on population size tends to include too many smaller species due to their higher abundance (Nee et al., 1991). Study I addresses this gap by providing, to my knowledge, the first rigorous and comprehensive approach to selecting bird species for knowledge surveys. Establishing a standardised baseline is essential for assessing public bird species knowledge, its determinants and effects, as explored in Studies II and III. By laying this foundation, Study I allows for meaningful comparisons and robust conclusions about bird species knowledge and its wider implications.

The first step of the three-step methodology involved a thorough database analysis to create a diverse and representative selection of bird species. This step integrated data from a variety of sources, including bird orders, breeding bird populations, CS platforms, public bird preferences, previous research on bird species knowledge, and literature (with a focus on textbooks and popular science books) (see page 38). The result was an initial list of 185 bird species.

The database analysis minimised bias and increased the robustness of species selection. Species from different orders and families were included to reflect the biodiversity of Germany's avifauna, as confirmed by a chi-square test comparing the selected species with the diversity of bird orders in Germany. This approach ensured that the list was ecologically representative. CS data played a central role in reducing habitat bias and strengthening the selection process. Four of the eight criteria were based on CS data, reflecting their increasing use in ecological research (Sullivan et al., 2014). CS data is invaluable for producing detailed distribution maps and monitoring changes in bird populations over time (McCaffrey, 2005). In addition, CS platforms highlight species that are most recognisable to the general public (Callaghan et al., 2022). The analysis included both: low-level CS monitoring projects, such as garden bird counts, and platforms for specialist birders, such as eBird, Ornitho and Club 300. This comprehensive inclusion of CS data helped to avoid over-representation of garden birds by capturing data from a range of habitats explored by experienced birders. The inclusion of public voting (NABU Bird of the Year election) and mentions in public literature ensured that the selection reflected species familiar to the public and relevant to conservation efforts, while mitigating population-based biases favouring smaller species.

The second step of the methodology involved an expert evaluation of the 185 species identified in the database analysis. Six experts and a group of 26 biology student teachers (treated as one aggregated expert) were asked to select bird species that they thought the general public should know. Participants were instructed to mark at least one species per avian order and, for songbirds, one species per family. Following this step, the list was reduced to 100 species. However, to maintain a representation of all avian orders and songbird families, two species (Eurasian Nightjar (*Caprimulgus europaeus*) and Bohemian Waxwing (*Bombycilla garrulus*)) were added back to ensure broader taxonomic inclusion.

Although a comparison of two EFAs – one with and one without the results of Expert Rating 1 – revealed only minimal differences, the inclusion of this step provided an important human dimension. The aim was to generate a list for public use, not just for scientific purposes. Using expert opinion ensured that the selection reflected societal relevance, in particular by including species that might be of interest to the general public. In addition, the involvement of biology student teachers was particularly valuable, as their connection to younger audiences and pedagogical expertise helps to ensure that the species selection is relevant and suitable for use in educational contexts (Marrero Galván et al., 2023). In contrast to previous studies that relied solely on expert judgement (e.g., Jaun-Holdererger, 2019; Zahner et al., 2007), the structured pre-selection through database analysis in this study provided experts with an evidence-based foundation to guide their decisions.

Beyond this step, the focus shifted from a strict taxonomic approach to creating a list that would be more relevant to society. This led to a larger expert survey aimed at refining the reduced list of 102 species. A panel of 197 experts from various fields evaluated each species, categorising them as ‘yes’, ‘probably’, or ‘no’ based on whether they should be known by the general public.

The strong correlation between the initial and subsequent expert ratings highlighted the effectiveness of smaller expert groups in choosing species for public knowledge surveys. While this finding suggests that large-scale expert surveys may not always be necessary, further replication of the process would be required to confirm this conclusively.

Nevertheless, the larger expert panel offered several advantages. First, the demographic composition of the panel was representative of broader societal trends. The average age of the experts was close to the average age of the German population (Rudnicka, 2022), and the slight over-representation of men reflected trends observed within the birdwatching community (Moore et al., 2008). Second, the panel was highly qualified, with most participants being active birdwatchers (75%) and more than half involved in nature conservation organisations or ornithological working groups. A significant proportion of participants (25%) had a university doctorate, but importantly, 22% came from non-university contexts. This diversity ensured that perspectives from different educational and experiential backgrounds were included, enriching the human dimension of the final list. The composition of the panel was therefore ideal for exploiting the ‘wisdom of the crowd’, where collective decisions of a diverse and knowledgeable group tend to be more reliable than those of individual experts (Krause et al., 2010). This was further supported by the validation of expert opinions through correlations with different datasets (e.g., CS platforms and breeding bird data). These analyses confirmed that the subjective judgements of the experts were highly consistent with the objective data, demonstrating the reliability of their ‘gut feeling’ in species selection.

In summary, Expert Ratings 1 and 2 played a crucial role in refining the species list and ensuring its societal relevance. The combination of small and large expert groups, together with rigorous database analysis, provided a well-grounded and robust basis for establishing a standardised baseline for bird species knowledge surveys.

The final list of bird species consists of 50 species, striking a balance between ecological diversity and societal relevance. While the choice of 50 species may initially appear arbitrary, it was guided by practical and methodological considerations. First, expert ratings naturally converged around this number, indicating a consensus on the most essential species for public knowledge. Second, 50 species is a manageable number for surveys, ensuring that the questionnaire remains engaging and holds the attention of participants (Sharma, 2022). The extended lists of 185 and 102 species provide flexibility to adapt according to specific research goals or contexts. For example, when surveying school students, a shorter list may be preferable to accommodate their limited attention spans (Slattery et al., 2022).

Three species – Common Magpie, Common Chaffinch (*Fringilla coelebs*), and Eurasian Blackbird – were unanimously considered essential by all experts. These species exemplify the list’s alignment with avian diversity and human familiarity. All three ranked in the Top 20 on all four CS platforms used in the study, and their population sizes were substantial, with the Common Magpie numbering 100,000 breeding pairs and both the Common Chaffinch and Eurasian Blackbird exceeding 1 million breeding pairs in Germany (Gedeon, 2015). Additionally, they appeared in at least six of the seven research studies reviewed and were featured in all six books analysed. However, only the Eurasian Blackbird placed in the Top 50 of the NABU Bird of the Year election, while the others did not, indicating some variation in public preferences.

The list also incorporates nearly all species commonly used in recent European bird species knowledge studies, with only minor exceptions due to regional differences in species composition (Cox & Gaston, 2015; Hooykaas et al., 2019; Jaun-Holderegger, 2019). The Canada Goose (*Branta canadensis*) occupies the final rank 50, with 41 of 197 experts supporting its inclusion. This is debatable as the Canada goose is a neozoon, but its inclusion reflects its increasing population trends in recent years. As other neozoon such as the Rose-ringed Parakeet (*Psittacula krameri*) continue to expand their range, future lists may need to account for their growing ecological and societal presence (Gerlach et al., 2019).

A list of 50 bird species that the general public should be familiar with can serve multiple valuable purposes. First, it provides a consistent baseline for knowledge surveys, allowing reliable comparisons between studies and tracking trends in bird species knowledge over time. By using the same species in future surveys, researchers can address the often-discussed but unproven decline in species knowledge (e.g., Frobel & Schlumprecht, 2016). In addition, the methodology used to compile the list can be applied to select species for other biogeographical regions and taxa, ensuring a well-grounded approach for wider use. In educational contexts, the list can guide curriculum development by highlighting the most important species for students to learn about. The inclusion of neozoons in the list could also stimulate discussion about their ecological impacts, while the list can be used to identify flagship species for conservation efforts.

4.1 Bird Species Knowledge among Adults and School Students

The 'golden 50' species list compiled in Study I was used to assess bird species knowledge in both adults (Study II) and school students (Study III). While adults were tested on all 50 species, the list was reduced to 30 species for school students to accommodate their shorter attention spans (Slattery et al., 2022). Despite this reduction, efforts were made to maintain taxonomic representativeness, including summer residents, winter visitors, nocturnal species such as owls, spatial coverage beyond garden birds, and a focus on local species (see Table 3.3.1).

4.1.1 Level of Bird Species Knowledge among School Students

In Study III, school students achieved an average identification score of 6.84 out of a possible 30 points, corresponding to 22.8% of the bird species tested being correctly identified. At the species level, students identified only 3.63 species (12%), whereas identification increased to 10.05 species (33.5%) when broader taxonomic levels such as family or order were included. Compared to recent surveys of bird species knowledge in Germany, the identification scores in this study were considerably lower. For example, Zahner et al. (2007) found that students in Bavaria were able to identify approximately one-third of 12 bird species, and Gerl et al. (2018) reported similar results for 15 species. Internationally, higher identification rates have been reported: students in Slovakia identified 39% of 25 species (Prokop et al., 2015), students in the US achieved a 35% identification score for 21 species (Egger et al., 2024), and students in the UK identified 31% of 18 species (Evans et al., 2006). It is important to note that these results are not directly comparable due to differences in study design, including variations in species selection, test methods and sample populations. However, these assessments show the consistent pattern that school students' identification skills are limited.

Students' familiarity with bird species varies widely, aligning with recent studies that highlight the best-known species. At the species level, Eurasian Blackbird, European Robin, and the Common Magpie were the most familiar. These findings are consistent with studies where the European Robin and Eurasian Blackbird were often the best known birds (Evans et al., 2006; Zahner et al., 2007). However, the Common Chiffchaff (*Phylloscopus collybita*) was the least known species in both categories. Several factors are likely to contribute to this low recognition rate. The Common Chiffchaff is a relatively inconspicuous bird, lacking the distinctive colouration or size that might make it more recognisable (eBird, 2025). Although the Common Chiffchaff sings its own name ('Zilpzalp' in German), a call well known to ornithologists and birders, studies such as Sturm et al. (2020) indicate that students often struggle to identify species based on sound alone. In addition, the Common

Chiffchaff is primarily a summer visitor to Germany, reducing students' opportunities for direct encounters compared to year-round resident species (eBird, 2025).

When broader taxonomic levels were included, the Carrion Crow (*Corvus corone*), Tawny Owl (*Strix aluco*) and Mallard emerged as the most familiar species. Many students identified these birds at order or family level. This may be because the students were aware of taxonomy but could not remember or name the species at the species level, or because they were not aware of the taxonomic hierarchy and believed that generic terms such as 'crow', 'owl' and 'duck' were sufficient to identify the species. This is consistent with the findings of Gerl et al. (2021), who found that taxonomy is rarely emphasised in German schools, and Atran et al. (2004), who found that students did not typically use taxonomic hierarchies to identify species. Similarly, Wilson et al. (2017) highlighted that the public often lacks awareness of species diversity, exemplified by the common misconception that there is only 'one' type of bee. These findings highlight a gap in formal taxonomic education, which may contribute to the low species identification rates observed.

Interestingly, the three best-known species at the species level ranked within the Top 10 of the 'golden 50' species list, whereas the best-known species at the order level did not. This underscores the quality of the list, as its goal was to prioritise individual species the public should know rather than broader taxonomic groups such as orders or families.

4.1.2 Sources of Bird Species Knowledge among School Students

The sources of students' bird species knowledge highlight the interplay between informal learning at home, formal education and media influences. In this study, parents and grandparents were the most commonly cited sources, with 78.3% of students attributing their bird species knowledge to these family members. This is consistent with previous studies in Germany, where the family was consistently identified as the primary source of species knowledge (Lindemann-Matthies et al., 2017). Similar findings have been reported internationally. For example, studies in Malta and England also identified parents as the main source of species knowledge among students (Gatt et al., 2007; Tunnicliffe & Reiss, 1998). In the US and Portugal, the home environment was found to be the most important learning context for children aged 10-15 years (Patrick et al., 2013). These findings highlight the critical role of the home environment in fostering early connections to biodiversity.

Teachers were the second most influential source in this study, mentioned by 54.1% of students. Although family members were identified as more influential, teachers remain essential contributors to students' learning about bird species. Frobel and Schlumprecht (2016) emphasised that educators play an important role not only as formal instructors, but also as mentors who can inspire curiosity and foster a deeper engagement with nature. As every child has to go through an educational process, teachers are invaluable in promoting species knowledge, for example through species identification exercises or field trips (e.g., Tenane, 2024).

Informal educators, such as nature guides and workshop leaders, were cited as mentors in bird species knowledge acquisition by 22.9% of students. This reflects the importance of non-formal learning opportunities that complement formal education and allow students to engage directly with nature in a more flexible and spontaneous way (Callanan et al., 2011). Schulte et al. (2019) highlight the value of informal mentoring relationships in fostering species knowledge, noting that these interactions often emphasise experiential learning and foster long-term interest in biodiversity.

Media sources played an important role in shaping students' bird species knowledge. Nature documentaries were the most frequently mentioned, with 66% of students identifying them as an important source. This is in line with findings from other countries, such as Iceland and England, where in 2008 television was identified as the most influential source of species knowledge (Patrick & Tunnicliffe, 2011). Books (58.3%) and the internet (60.6%) were also prominent sources in Study III, the latter reflecting the increasing accessibility of educational content through digital platforms. Interestingly, social media ranked lower (38%), but remains an emerging avenue for biodiversity education, especially among the youth. Studies have shown that digital tools such as bird species identification apps can complement traditional media and improve knowledge retention (Vanhöfen et al., 2023).

4.1.3 Shifts in Bird Species Knowledge among School Students

Differences in study design limit the direct comparability of recent (bird) species knowledge surveys. To address this, a comparison has been made with a 2005 dataset from Randler (2008a), which used the same methodology. Students were asked to identify 28 of the 30 bird species from pictures and write down the correct species names. In addition, participants in the two studies were similar in terms of average age, gender distribution and school type. All participating schools were located in Baden-Württemberg, which ensured consistency in regional and educational contexts. These factors allowed a direct comparison of the two datasets, providing robust evidence of changes in bird species knowledge between 2005 and 2022/2023.

The results of Study III show a significant decline in the ability to identify bird species in 2022/2023 compared to 2005. Identification scores, which included recognition at family or order level, decreased by 9.53% over 18 years. The decline at species level was even more pronounced, with a drop of 37.75%. These results show that students nowadays can name far fewer bird species than their counterparts nearly two decades ago.

A comparison of identification scores across school types and survey years shows a marked decline in bird species knowledge. Scores at the highest stratification level now match the medium level from 2005, and there have also been declines at the primary and medium levels. Structural changes in the school system, such as the abolition of the mandatory primary school recommendation for transition to secondary school in 2012 (Statistisches

Landesamt BW, 2013) and the gradual elimination of the lowest stratification level by 2016 (GEW BW, 2016), may partly explain this trend. However, these changes alone cannot explain the almost 38% decline in identifying species and the 10% overall decline, which means that there must be other underlying reasons.

One possible contributing factor are the changes in school curricula in Baden-Württemberg. At the highest stratification level, the 1994 curriculum emphasised ‘species knowledge’ (*Artenkenntnis*), ‘nature conservation’ (*Naturschutz*) and ‘species protection’ (*Artenschutz*), but these topics were less prominent or absent in the 2004 curriculum (MKJS BW, 1994a, 2004a). Although topics such as ‘ecology’ (*Ökologie*) regained some prominence in 2016, species knowledge remained limited to lower grades (5/6), with bird-related content focusing on broad concepts such as flight adaptations and reproduction rather than species identification. While the inclusion of ‘biodiversity’ (*Biodiversität*) in the 2016 curriculum was a positive step, it remains general, with very little focus on species knowledge (MKJS BW, 2016a, 2016b).

While the 1994 curriculum included species identification exercises to foster species knowledge (MKJS BW, 1994c), species knowledge was largely omitted from the 2004 medium-level curriculum (MKJS BW, 2004c). In 2016, a unified curriculum was introduced for grades 5-10 in all secondary schools, but species knowledge was still kept to a minimum (MKJS BW, 2016d, 2016e). At primary level, the provision of food and nesting sites for birds was included in the curriculum in 1994 (MKJS BW, 1994b), two activities that have been shown to improve species knowledge (Cox & Gaston, 2015). Ten years later, the curriculum encouraged bird watching but provided little detailed guidance on species identification (MKJS BW, 2004b). Since 2016, the focus has shifted to species representative of specific habitats, but bird species diversity is still not a central topic (MKJS BW, 2016c). In summary, the greater emphasis on species knowledge in pre-2004 curricula is likely to have contributed to the higher bird identification skills observed in the 2005 sample. From 2004 to 2016, species knowledge was deprioritised, and although topics such as ‘biodiversity’ and ‘ecology’ have since gained in importance, the teaching of species-specific knowledge, particularly about birds, remains limited. This shift in focus may be a key factor in the observed decline.

The drop in bird species knowledge cannot be attributed solely to changes in curricula. Declining bird populations have significantly reduced opportunities for students to observe birds in their natural habitat (Kamp et al., 2021). This is further exacerbated by the extinction of experience, where adolescents have increasingly limited contact with nature (e.g., Murciano-Hueso et al., 2024; Soga & Gaston, 2016). With fewer opportunities to engage with nature, the foundational experiences that foster species knowledge are increasingly absent (Longbottom & Slaughter, 2016).

Intergenerational knowledge transfer also plays a critical role in this decline. Parents and grandparents remain students' primary sources of species knowledge, as shown in Study III. However, older generations tend to have greater bird species knowledge (Enzensberger et al., 2022), and this knowledge transfer appears to be declining in recent years. An important factor contributing to this trend is the decline of multigenerational households in many European countries, where fewer grandparents live with their grandchildren, limiting opportunities for intergenerational learning (Glaser et al., 2018).

A lack of teacher expertise in species knowledge further exacerbates the problem. Changes in university curricula have increasingly emphasised genetics and molecular biology to the disadvantage of zoology and botany, resulting in fewer biology teachers well trained in species knowledge. Specialisation within academia has limited the number of broadly trained educators who can effectively teach species knowledge to future teachers (Frobel & Schlumprecht, 2016). As a result, students receive less exposure to species knowledge in the classroom, further contributing to the decline.

Taken together, these factors illustrate the complex interplay of environmental, social and educational changes that are driving the decline in bird species knowledge. If left unaddressed, this loss of knowledge could exacerbate the shifting baseline syndrome, where the decline in biodiversity becomes normalised across generations (Leather & Quicke, 2009).

4.1.4 Influence of Demographic Factors on School Students' Bird Species Knowledge

Demographic factors such as age, gender, education, frequency of garden visits and distance from home to the nearest green space significantly influenced students' knowledge of bird species in Study III. Gender had a negligible effect, consistent with the mixed results of previous studies (e.g., Eschenhagen, 1982; Zahner et al., 2007). This suggests that gender is unlikely to play a decisive role in shaping bird species knowledge.

Age showed a small but significant effect, supporting previous findings (e.g., Hooykaas et al., 2019). Older students generally performed better, which may reflect accumulated exposure to nature and learning environments over time (Randler & Heil, 2021). Interestingly, bird species knowledge peaked at age 12, then declined during early adolescence, followed by a gradual increase until age 18. This peak, which occurred earlier than those identified by Randler (2008a) (age 14) and Gerl et al. (2018) (age 15), may be due to curriculum changes in 2016 that concentrated zoology content in grades 5 and 6. The reduced level of knowledge between ages 13 and 15 may be due to a decline in interest in biology during adolescence (Bebbington, 2005), and the curricular focus on human biology during these years (MKJS BW, 2016a).

School type had the strongest effect on bird species knowledge. Students attending high-level schools consistently outperformed their peers at medium and primary levels, a trend

observed in previous research (e.g., Randler, 2008a; Zahner et al., 2007). While curricular differences between school types in species knowledge at secondary level are minimal, differences in family background may explain these findings. Children from families with higher levels of education are more likely to attend higher performing schools and may benefit from greater exposure to bird species knowledge at home (Davis-Kean, 2005). In addition, these families often have the financial means to support extra-curricular activities, such as nature trips, which are known to enhance species knowledge (Card, 1999). The number of garden visits per week and proximity to green spaces also significantly influenced bird species knowledge. These factors likely reflect increased opportunities for direct interaction with nature. Urban gardeners in Germany, who tend to have higher levels of education (Winkler et al., 2019), may further contribute to this relationship by fostering an environment where children are more likely to learn about biodiversity.

4.1.5 Influence of Individual Factors on Bird Species Knowledge

Individual factors determining bird species knowledge were found to be very similar in Studies II and III for both school students and adults.

Interest in birds was shown to be the most powerful predictor of bird species knowledge in both studies. Such a finding points towards the importance of achievement emotions, particularly interest in fostering an individual's connection with biodiversity. People who are particularly interested in birds are more likely to find ways of observing, learning about, and engaging with nature (Ainley et al., 2002; Pekrun et al., 2002). Interest supports this process through enhancing curiosity and focused attention, thereby facilitating knowledge acquisition (Gläser-Zikuda et al., 2005; Harackiewicz et al., 2016). The strong influence of interest is consistent with broader findings in environmental education research. Promoting interest not only improves knowledge but also promotes pro-environmental behaviours (Neurohr et al., 2023; Palmberg et al., 2015).

Both studies found that animal-related activities positively influences bird species knowledge. Feeding birds, observing wildlife, and visiting zoos or natural history museums provide hands-on, experiential forms of learning which increase the knowledge of different species (Schwichow et al., 2016). Animal-related activities enhance the potential for being able to see a bird, identify what its species traits are, and observe its behaviour and ecology while it is still in its natural environment. This makes it easier to distinguish between bird species (Cox & Gaston, 2016). Regular participation in animal-related activities promotes repeated identification of species, which is important for long-term knowledge retention (Cosquer et al., 2012). For children, such activities are often within informal settings, filling gaps left by formal education (Kuo et al., 2019). Furthermore, activities such as installing nesting boxes or participating in CS programmes not only improve species knowledge but also promote environmental stewardship (Cooper et al., 2007; Randler, 2021b).

The perception of birds was found to differ in its influence on bird species knowledge between adults and school students. In adults, perception was negatively associated with bird species knowledge, which may be due to cognitive biases or inaccurate assumptions based on personal experience (Stammers, 2019). For example, even if adults have developed some positive feelings towards birds, such as appreciating their aesthetic or emotional value (Belaire et al., 2015), this will not necessarily translate into factual knowledge about birds or identification skills. Adults with higher levels of the personality trait *agreeableness* may conform to social expectations by expressing positive perceptions about birds, although they have low levels of bird species knowledge (Sheese & Graziano, 2004; Smillie et al., 2015).

For students, on the other hand, perception of birds did not influence their bird species knowledge. This might be due to a developmentally based difference in the way perceptions are formed and expressed. Younger children are probably offering more straightforward and intuitive answers to their feelings concerning birds, as their perceptions generally hold less weight from social norms or personality traits. However, as children go through the adolescent phase, their responses may be increasingly influenced by external expectations and may thus be more in line with social attitudes (Schmidt & Rakoczy, 2023). This developmental shift probably accounts for the positive association between perception and species knowledge reported by R. L. White et al. (2018) in children ages 7-10, who may have more direct associations between liking birds and their knowledge. Given that Study III focused on older students, this observed positive relationship may no longer be present. In summary, the contrasting results between adults and school students highlight the complex interplay between age, personality and cognitive factors in shaping the relationship between perception and bird species knowledge.

Interestingly, connectedness to nature had no significant impact on bird species knowledge in either group. However, previous studies have found a weak but significant association between connectedness to nature and environmental knowledge (Roczen et al., 2014). It seems that connectedness to nature and bird species knowledge may work through different processes, as connectedness is primarily derived from experience and emotion, whereas bird species knowledge typically arises from factual learning (Geng et al., 2015). While hands-on experience in nature contributes to bird species knowledge (e.g., Shin et al., 2024), an emotional connection to nature cannot guarantee effective learning about particular species. For instance, people who feel deeply connected to nature may enjoy spending time outdoors, but their activities might not involve paying close attention to or learning about the bird species they encounter (Zelenski & Nisbet, 2014). In addition, it is possible that connectedness to nature is more closely related to knowledge of other species, such as plants, than to bird species, but this was not investigated in the present research.

4.1.6 Effect of Bird Species Knowledge on Environmental Attitudes

Bird species knowledge has a significant influence on environmental attitudes, particularly in promoting eco-centric attitudes. Study II shows that individuals with higher species knowledge have stronger preservation attitudes, valuing nature for its intrinsic worth and advocating for its conservation (e.g., Bogner & Wilhelm, 1996; Randler et al., 2024). This is consistent with findings by Härtel, Randler, and Baur (2023), who showed that students' species knowledge positively influences their pro-environmental attitudes, suggesting that this relationship holds across age groups. Thus, bird species knowledge can be seen as a foundation for fostering pro-environmental attitudes, a connection often discussed by conservationists (e.g., Leather & Quicke, 2009).

Interestingly, bird species knowledge was negatively associated with anthropocentric attitudes, implying that a person with higher levels of knowledge is less likely to support the exploitation of nature (e.g., Randler et al., 2024). While the 2-MEV model suggests that preservation and utilisation of natural resources represent two independent dimensions, actual studies have revealed some slight correlations between the two (Nkaizirwa et al., 2022). This indicates that promoting preservation through species knowledge may reduce anthropocentric views, although supporting one dimension does not necessarily mean denying the other (Boeve-de Pauw & Van Petegem, 2013).

The findings supplement broader research indicating a significant effect on pro-environmental attitudes due to environmental knowledge (e.g., Roczen et al., 2014). Recent studies demonstrated that having higher levels of species knowledge would result in a more favourable attitude toward animals (e.g., Melis et al., 2021) and practised prosocial behaviours, like donating to environmental causes (Lundberg et al., 2019). These findings highlight the important role of bird species knowledge in shaping environmental attitudes and fostering a deeper commitment to conservation (Rohrschneider & Miles, 2015).

5 Limitations

Regarding Study I, the 3-step approach and the inclusion of several databases and many experts attempted to minimise bias in the final selection of species. However, there are several limitations to the methodology. First, expert judgement is inherently subjective, influenced by personal experience or regional familiarity, which may introduce bias. However, expert judgement was validated by significant correlation with several databases, minimising the potential for bias. Second, the predominantly central European focus of the databases limits their applicability to other regions with different bird populations, cultural perceptions and conservation priorities. Nevertheless, this limitation could be overcome by adapting the methodology and using region-specific databases where available. Third, CS platforms tend to over-represent conspicuous species (Callaghan et al., 2021), which may bias the initial species list. However, the inclusion of four CS platforms with different levels of engagement aimed to minimise this bias. Furthermore, while consistency is essential for monitoring trends over time, regular updates to the species list may be necessary to reflect changes in bird populations or changing conservation priorities. These updates could potentially undermine long-term comparability. But, by applying the same rigorous selection methodology in the future, species lists that differ slightly could still remain comparable. Nevertheless, future research is needed to assess how such updates might affect the ability to track changes in species knowledge over time. Finally, the methodology may be difficult to apply to broader taxa such as insects or plants due to differences in data availability and expert networks. However, a growing number of global CS platforms offer valuable resources for various taxa, including plants (Sullivan et al., 2014). Platforms such as iNaturalist.org, Observation.org, and Naturespot.net ensure data quality and reliability through expert validation (Observation.org, 2025). Notably, iNaturalist alone has approximately 3.5 million users (iNaturalist, 2025). Regional platforms such as Mammalnet.com, which focuses on European mammals, further extend these capabilities. In addition, population reports for various taxa as well as hunting and fishing statistics, could provide supplementary data to support species selection (Härtel, Randler, & Baur, 2023).

There were also some limitations to the surveys of adult and student species knowledge in Studies II and III. First, a participation bias may have influenced the adult study, as individuals with a greater interest in birds were likely to be more motivated to participate. As far as known, the study is among the largest of its kind worldwide, which may reduce bias by including a broader and more diverse sample. For school students, this bias was probably reduced by teacher-selected participation and parental consent. However, as the consent form was written in German, students with non-German speaking parents may have been under-represented. As participation was voluntary, overcoming such biases is

inherently challenging. Second, although unidirectional relationships were found between individual factors and knowledge of bird species, bidirectional relationships or feedback loops cannot be excluded. Longitudinal studies over several years are needed to establish causality more conclusively. Third, although several individual factors were considered, additional variables may influence bird species knowledge. Future research should explore other potential determinants to provide a more comprehensive understanding. Fourth, the adult study included participants from almost all German federal states, whereas the student study was limited to Baden-Württemberg. This regional limitation makes it difficult to generalise the findings internationally. Nevertheless, the findings are of international relevance, as similar declines have been suggested in other countries (e.g., Löbl et al., 2023; Papworth et al., 2009). Extending the study to other regions or countries would increase its applicability. Finally, while the students surveyed in 2022/2023 were comparable to those surveyed in 2005 in terms of age, gender and school type, the more extensive questionnaire in the 2022/2023 study may have introduced fatigue effects. However, students were given sufficient time to complete the survey, which mitigates this issue to some extent.

6 Implications and Outlook

This research has several important implications for future studies on bird species knowledge and educational contexts. For a start, the rigorous and comprehensive approach used to compile the ‘golden 50’ list provides a solid basis for future assessments of (bird) species knowledge. Future research is encouraged to adopt either the methodology or the list itself to allow reliable comparisons between studies and to track changes in species knowledge over time. Beyond research, the list has other applications, such as supporting curriculum development in education and selecting flagship species for conservation efforts. Next, the relatively low level of bird species knowledge among today’s students, coupled with the evidence of a decline over the past two decades, highlights an urgent need for action. This need is further emphasised by the relationship between bird species knowledge and environmental attitudes, as shown in Study II. Increasing bird species knowledge is not only an academic goal, but also a way to foster stronger eco-centric attitudes, which are crucial for understanding the importance of conservation (Rohrschneider & Miles, 2015). While it remains uncertain whether eco-centric attitudes always translate into sustainable behaviour (Wyss et al., 2022), some studies suggest a positive association (Handayani et al., 2021). Promoting species knowledge could therefore contribute to achieving a more sustainable future, as targeted by the SDGs (UN, 2015).

The following recommendations for educational practice are drawn directly from the discussion. Educational reforms are particularly valuable because all children participate in education, making it an effective way to promote equal opportunities regardless of family background. Children are also an ideal target group for biodiversity education, because they are more open to new ideas than adults and can also impact the behaviour of the adults around them (Barker & Elliott, 2000).

As changes in school curricula may be one reason for the decline in bird species knowledge, curricula should be revised to include more content on species identification, especially in grades 7 and above. This could help bridge the knowledge gap between lower and higher grades. Repetition, which is essential for effective learning (e.g., Kang, 2016), could also prevent the decline observed in adolescents.

Despite the important role of parents and grandparents in fostering species knowledge, the importance of teachers should not be underestimated. As many teachers currently feel underprepared to teach species knowledge (Magntorn & Helldén, 2005), university courses for student teachers should place more emphasis on zoology and botany, rather than focusing exclusively on topics such as genetics. Better prepared teachers would feel more confident in teaching (bird) species knowledge and could play a crucial role in passing this knowledge on to future generations.

Generating interest in birds and engaging students in animal-related activities are key strategies for teaching bird species knowledge. Guided field trips that stimulate interest through direct observation of the natural world are particularly effective (e.g., Rijal et al., 2018). Expanding access to green spaces and establishing school gardens, coupled with their active use, would provide additional opportunities for students to engage with nature (e.g., Kong & Chen, 2024). These efforts would also help to reduce inequalities between urban and rural students by ensuring that those without gardens at home or with limited access to green spaces can still interact with nature. Increased contact with nature is essential to combat the extinction of experience that diminishes people's connection with the natural world (Soga & Gaston, 2016).

However, given the logistical challenges of organising field trips, future research should explore methods for effectively promoting bird species knowledge in shorter classroom settings. Used properly, digital media like nature documentaries and species identification apps provide an accessible and engaging alternative that fits well into the classroom environment (Welsh et al., 2013). If the aim is to promote general species knowledge, incorporating living organisms into the classroom can further enhance motivation and deepen learning (Wilde et al., 2012).

Formal education could be complemented by providing more CS programmes with low barriers to access and free participation, ensuring inclusivity across all social groups. Shared experiences, especially when family members participate together, can greatly enhance the students' identification skills regarding plants and animals (Helldén & Helldén, 2008). CS offers an excellent way of engaging with nature and developing species knowledge while providing opportunities for active participation in scientific research (Domroese & Johnson, 2017; Schuttler et al., 2018). This can be particularly beneficial when integrated into a school setting (Bonney et al., 2016).

When teaching bird species, it is important to emphasise taxonomy and relationships within bird species. Biology teachers and informal educators must use proper scientific nomenclature at the species level to mitigate misconceptions, such as the belief that 'owl' or 'duck' represents the highest taxonomic classification. To promote a comprehensive understanding of avian biodiversity, educators should not only focus on conspicuous birds, but also include well-camouflaged and smaller species such as the Common Chiffchaff and the Eurasian Blackcap (*Sylvia atricapilla*). The species list produced by this research provides a good starting point.

Forward-looking, by promoting bird species knowledge, we are equipping future generations to address the pressing challenges of biodiversity conservation. This aligns with the ESD goals outlined in the SDG, which emphasise the development of knowledge, skills, values and abilities to address issues such as biodiversity loss (UNESCO, 2021). In addition, improving species knowledge could help counteract the shifting baseline syndrome and prevent the normalisation or neglect of biodiversity loss (Leather & Quicke, 2009). Future research should focus on developing innovative, inclusive and accessible methods for teaching bird species knowledge in different settings.

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9 Appendix

- Study I – A1: Pre-Selection: 185 Species List
- Study I – A2: Pre-Selection: 102 Species List
- Study I – A3: Questionnaire Expert Rating II
- Study II – A1: Questionnaire Adults
- Study III – A1: Questionnaire School Students

We used the following bird images from the Cornell Lab of Ornithology | Macaulay Library in the questionnaires, which are included in the Appendix (Study II – A1 & Study III – A1):

ML204602731, ML325091821, ML63370131, ML374021091, ML374034201, ML250522781, ML39278421, ML221765361, ML138935991, ML291069121, ML179867391, ML91375081, ML51357991, ML98180411, ML328359921, ML204456581, ML202705551, ML314381861, ML59579951, ML63379971, ML278619281, ML204247951, ML181348911, ML348838051, ML67125821, ML395028571, ML343012681, ML299607361, ML464201451, ML172974031, ML414257861, ML23443721, ML188708831, ML449403701, ML211672961, ML78557031, ML64192551, ML191052481, ML255272571, ML303953581, ML35496821, ML89004051, ML63678081, ML359832531, ML204656501, ML46363871, ML144916421, ML481506961, ML35081921, ML40358641

Scientific Name	Species	Garden Birdwatch	Bird of the Year	Ornitho	eBird	Breeding Bird Atlas	Club 300	Previous Studies	Books
39	<i>Caprimulgus europaeus</i>	Eurasian Nighthjar							
40	<i>Carduelis carduelis</i>	European Goldfinch	18	33	24	2	14	1	1
41	<i>Certhia brachydactyla</i>	Short-toed Treecreeper	55		40	2	9		
42	<i>Certhia familiaris</i>	Eurasian Treecreeper	102			2			
43	<i>Charadrius dubius</i>	Little Ringed Plover							1
44	<i>Charadrius hiaticula</i>	Common Ringed Plover							
45	<i>Chloris chloris</i>	European Greenfinch	12	34	26	3	14	5	5
46	<i>Chroicocephalus ridibundus</i>	Black-headed Gull	67	41	28	2	14	2	2
47	<i>Ciconia ciconia</i>	White Stork	38	47	67		15	1	1
48	<i>Ciconia nigra</i>	Black Stork	116						
49	<i>Cinclus cinclus</i>	White-throated Dipper	113			1		1	1
50	<i>Circus aeruginosus</i>	Western Marsh Harrier	121		81		11		
51	<i>Circus cyaneus</i>	Hen Harrier							1
52	<i>Coccothraustes coccothraustes</i>	Hawfinch	41			2	6		
53	<i>Coleus monedula</i>	Eurasian Jackdaw	23	48	39	1	14	2	2
54	<i>Columba livia f. domestica</i>	Feral Pigeon	17	5	35	2		1	1
55	<i>Columba oenas</i>	Stock Dove	74		92	1			
56	<i>Columba palumbus</i>	Common Wood-Pigeon	9	8	4	3	13	2	2
57	<i>Corvus corax</i>	Common Raven	44	43	61	1	9		
58	<i>Corvus cornix</i>	Hooded Crow	36		60	1	6	1	1
59	<i>Corvus corone</i>	Carrion Crow	14	49	5	3	10	3	3
60	<i>Corvus frugilegus</i>	Rook	20		75	1	12		
61	<i>Coturnix coturnix</i>	Common Quail				1			
62	<i>Cuculus canorus</i>	Common Cuckoo	49	19	66	1	10	1	1
63	<i>Cyanistes caeruleus</i>	Eurasian Blue Tit	5	8	9	3	15	5	5
64	<i>Cygnus cygnus</i>	Whooper Swan						1	1
65	<i>Cygnus olor</i>	Mute Swan	73		16	25	1	17	
66	<i>Delichon urbicum</i>	Common House Martin	10	20	49	2	12		
67	<i>Dendrocopos major</i>	Great Spotted Woodpecker	19	41	17	11	2	15	4
68	<i>Dendrocoptes medius</i>	Middle Spotted Woodpecker	87			1			
69	<i>Dryobates minor</i>	Lesser Spotted Woodpecker	123			1			
70	<i>Dryocopus martius</i>	Black Woodpecker	75		93	1	2		
71	<i>Emberiza calandra</i>	Corn Bunting	130			1			
72	<i>Emberiza citrinella</i>	Yellowhammer	42	39	23	3	9	1	1
73	<i>Emberiza hortulana</i>	Ortolan Bunting				1			
74	<i>Emberiza schoeniclus</i>	Common Reed Bunting	128			2	6		
75	<i>Erithacus rubecula</i>	European Robin	11	1	10	3	13	7	7
76	<i>Falco columbarius</i>	Merlin							1
77	<i>Falco peregrinus</i>	Peregrine Falcon	85				5		
78	<i>Falco subbuteo</i>	Eurasian Hobby	108	18					
79	<i>Falco tinnunculus</i>	Common Kestrel	32	14	27	1	16		
80	<i>Ficedula albicollis</i>	Collared Flycatcher							1
81	<i>Ficedula hypoleuca</i>	European Pied Flycatcher	65			1			
82	<i>Fringilla coelebs</i>	Common Chaffinch	13	7	6	3	14	6	6

	Scientific Name	Species	Garden Birdwatch	Bird of the Year	Ornitho	eBird	Breeding Bird Atlas	Club 300	Previous Studies	Books
83	<i>Fringilla montifringilla</i>	Brambling	95						5	
84	<i>Fulica atra</i>	Eurasian Coot	61		21	17	1	13	2	2
85	<i>Galerida cristata</i>	Crested Lark		33						
86	<i>Gallinago gallinago</i>	Common Snipe				97			5	
87	<i>Gallinula chloropus</i>	Common Moorhen	78		50	45	1	14	1	1
88	<i>Garrulus glandarius</i>	Eurasian Jay	22	26	30	20	2	14	1	1
89	<i>Grus grus</i>	Common Crane	71		27	84		12		
90	<i>Haematopus ostralegus</i>	Eurasian Oystercatcher	88				1	8		
91	<i>Haliaeetus albicilla</i>	White-tailed Eagle	107					1		
92	<i>Hippolais icterina</i>	Icterine Warbler	100				2			
93	<i>Hirundo rustica</i>	Barn Swallow	16	2	39	29	2	14	2	2
94	<i>Jynx torquilla</i>	Eurasian Wryneck	104							
95	<i>Lanius collurio</i>	Red-backed Shrike	105			99	1	7		
96	<i>Larus argentatus</i>	European Herring Gull	66			65	1	11		
97	<i>Larus canus</i>	Common Gull	80			85	1			
98	<i>Larus fuscus</i>	Lesser Black-backed Gull	115				1			
99	<i>Larus michahellis</i>	Yellow-legged Gull	122			87				
100	<i>Limosa limosa</i>	Black-tailed Godwit							1	1
101	<i>Linaria cannabina</i>	Common Linnet	50	24		68	2	7		
102	<i>Locustella naevia</i>	Common Grasshopper Warbler					1			
103	<i>Lophophanes cristatus</i>	Crested Tit	64				2			
104	<i>Loxia curvirostra</i>	Red Crossbill					1			
105	<i>Lullula arborea</i>	Woodlark					1			
106	<i>Luscinia luscinia</i>	Thrush Nightingale	117							
107	<i>Luscinia megarhynchos</i>	Common Nightingale	43			91	1		1	1
108	<i>Luscinia svecica</i>	Bluethroat						2		
109	<i>Lyrurus tetrix</i>	Black Grouse								1
110	<i>Mareca penelope</i>	Eurasian Wigeon				78		7		
111	<i>Mareca strepera</i>	Gadwall			45	38		9		
112	<i>Mergus merganser</i>	Common Merganser	111			72		10		
113	<i>Merops apiaster</i>	European Bee-eater	79	40						
114	<i>Milvus migrans</i>	Black Kite	81			90		6		
115	<i>Milvus milvus</i>	Red Kite	25	11	11	47	1	13		
116	<i>Morus bassanus</i>	Northern Gannet		34						
117	<i>Motacilla alba</i>	White Wagtail	26	48	25	22	2	13	1	1
118	<i>Motacilla cinerea</i>	Grey Wagtail	98			89	1	5		
119	<i>Motacilla flava</i>	Western Yellow Wagtail	90			76	1	8		
120	<i>Muscicapa striata</i>	Spotted Flycatcher	69				2			
121	<i>Netta rufina</i>	Red-crested Pochard				100				
122	<i>Numenius arquata</i>	Eurasian Curlew		47				4		
123	<i>Oenanthe oenanthe</i>	Northern Wheatear						5		
124	<i>Oriolus oriolus</i>	Eurasian Golden Oriole	72	35			1			
125	<i>Pandion haliaetus</i>	Osprey		50						
126	<i>Parus major</i>	Great Tit	3		4	2	3	15	6	6

	Scientific Name	Species	Garden Birdwatch	Bird of the Year	Ornitho	eBird	Breeding Bird Atlas	Club 300	Previous Studies	Books
127	<i>Passer domesticus</i>	House Sparrow	1	6	28	14	3	12	5	5
128	<i>Passer montanus</i>	Eurasian Tree Sparrow	6	22		46	2	8		
129	<i>Perdix perdix</i>	Grey Partridge	109	14			1		1	1
130	<i>Periparus ater</i>	Coal Tit	48			79	3	2	1	1
131	<i>Pernis apivorus</i>	European Honey Buzzard								
132	<i>Phalacrocorax carbo</i>	Great Cormorant	76		18	16	1	16		
133	<i>Phasianus colchicus</i>	Common Pheasant	59			64	2	15	1	1
134	<i>Phoenicurus ochruros</i>	Black Redstart	21	44	42	37	2	9	3	3
135	<i>Phoenicurus phoenicurus</i>	Common Redstart	28	12			1	10		
136	<i>Phylloscopus collybita</i>	Common Chiffchaff	34		15	12	3	8	2	2
137	<i>Phylloscopus sibilatrix</i>	Wood Warbler	125				2			
138	<i>Phylloscopus trochilus</i>	Willow Warbler	63			63	2	6		
139	<i>Pica pica</i>	Common Magpie	8		19	10	2	15	6	6
140	<i>Picus canus</i>	Grey-headed Woodpecker	124				1			
141	<i>Picus viridis</i>	Eurasian Green Woodpecker	40	31	24	30	1	13		
142	<i>Platalea leucorodia</i>	Eurasian Spoonbill		15						
143	<i>Pluvialis apricaria</i>	European Golden Plover		7						
144	<i>Podiceps cristatus</i>	Great Crested Grebe	93		36	36	1	13	2	2
145	<i>Podiceps nigricollis</i>	Black-necked Grebe		21						
146	<i>Poecile montanus</i>	Willow Tit	67				1			
147	<i>Poecile palustris</i>	Marsh Tit	57			56	2	7	1	1
148	<i>Prunella modularis</i>	Duncock	33			48	3	7		
149	<i>Psittacula eupatria</i>	Alexandrine Parakeet	114							
150	<i>Psittacula krameri</i>	Ring-necked Parakeet	56							
151	<i>Pyrrhula pyrrhula</i>	Eurasian Bullfinch	30	25		59	2	9	2	2
152	<i>Rallus aquaticus</i>	Water Rail					1			
153	<i>Recurvirostra avosetta</i>	Pied Avocet								1
154	<i>Regulus ignicapilla</i>	Common Firecrest	82			96	3			
155	<i>Regulus regulus</i>	Goldcrest	97	38		70	3	10		
156	<i>Riparia riparia</i>	Sand Martin	129				2			
157	<i>Saxicola rubetra</i>	Whinchat		32			1	1		
158	<i>Saxicola rubicola</i>	European Stonechat	120			95	1	6		
159	<i>Scolopax rusticola</i>	Eurasian Woodcock					1			
160	<i>Serinus serinus</i>	European Serin	45			98	2			
161	<i>Sitta europaea</i>	Eurasian Nuthatch	29	37	37	23	3	14	3	3
162	<i>Spatula clypeata</i>	Northern Shoveler				73		9		
163	<i>Spinus spinus</i>	Eurasian Siskin	54			62	1	3	1	1
164	<i>Streptopelia decaocto</i>	Eurasian Collared Dove	15			57	2	12	1	1
165	<i>Streptopelia turtur</i>	European Turtle Dove	77				1			
166	<i>Strix aluco</i>	Tawny Owl	103				1		2	2
167	<i>Sturnus vulgaris</i>	Common Starling	4	17	13	9	3	14	4	4
168	<i>Sylvia atricapilla</i>	Eurasian Blackcap	24		22	21	3	10	1	1
169	<i>Sylvia borin</i>	Garden Warbler	53			94	2			
170	<i>Sylvia communis</i>	Common Whitethroat	84			74	2	2		

	Scientific Name	Species	Garden Birdwatch	Bird of the Year	Ornitho	eBird	Breeding Bird Atlas	Club 300	Previous Studies	Books
171	<i>Sylvia curruca</i>	Lesser Whitethroat	58				2			
172	<i>Tachybaptus ruficollis</i>	Little Grebe			44	54	1	9		
173	<i>Tadorna ferruginea</i>	Ruddy Shelduck	101							
174	<i>Tadorna tadorna</i>	Common Shelduck				88		10		
175	<i>Tetrao urogallus</i>	Western Capercaillie		16						
176	<i>Tringa totanus</i>	Common Redshank					1	3		
177	<i>Troglodytes troglodytes</i>	Eurasian Wren	31	29	26	18	3	14	1	1
178	<i>Turdus iliacus</i>	Redwing								
179	<i>Turdus merula</i>	Eurasian Blackbird	2	10	1	1	3	15	7	7
180	<i>Turdus philomelos</i>	Song Thrush	37		38	33	3	11		
181	<i>Turdus pilaris</i>	Fieldfare	47		40	41	2	7		
182	<i>Turdus viscivorus</i>	Mistle Thrush	96			83	2	6		
183	<i>Tyto alba</i>	Barn Owl					1			
184	<i>Upupa epops</i>	Eurasian Hoopoe	99	13						
185	<i>Vanellus vanellus</i>	Northern Lapwing	86	3	35	52	1	13	1	1

Results of Step II:

Shown is the ranking after exploratory factor analysis (EFA) with the following variables: expert round 1, eBird, Ornitho, Club 300, Garden Birdwatch (NABU), previous studies, Bird of the Year (NABU), books and Breeding Bird Census (ADEBAR) sorted by the z-values.

In addition, the results of EFA 2 (without experts) are presented, as well as the ranks of the final 'golden 50' species list.

	<i>scientific name</i>	english name	EFA with experts		EFA without experts		golden 50
			rank	z-value	rank	z-value	
1	<i>Turdus merula</i>	Eurasian Blackbird	1	2.926	1	-3.122	3
2	<i>Parus major</i>	Great Tit	2	2.638	2	-2.799	4
3	<i>Cyanistes caeruleus</i>	Eurasian Blue Tit	3	2.585	3	-2.723	11
4	<i>Fringilla coelebs</i>	Common Chaffinch	4	2.569	4	-2.720	2
5	<i>Erithacus rubecula</i>	European Robin	5	2.508	5	-2.641	8
6	<i>Sturnus vulgaris</i>	Common Starling	6	2.378	6	-2.485	7
7	<i>Passer domesticus</i>	House Sparrow	7	2.375	7	-2.481	13
8	<i>Anas platyrhynchos</i>	Mallard	8	2.242	8	-2.329	12
9	<i>Dendrocopos major</i>	Great Spotted Woodpecker	9	2.11	9	-2.173	10
10	<i>Chloris chloris</i>	European Greenfinch	10	2.07	10	-2.141	23
11	<i>Pica pica</i>	Common Magpie	11	1.833	11	-1.868	1
12	<i>Sitta europaea</i>	Eurasian Nuthatch	12	1.764	12	-1.779	33
13	<i>Corvus corone</i>	Carrion Crow	13	1.754	13	-1.769	31
14	<i>Buteo Buteo</i>	Common Buzzard	14	1.749	14	-1.753	17
15	<i>Columba palumbus</i>	Common Wood Pigeon	15	1.689	15	-1.700	34
16	<i>Phoenicurus ochruros</i>	Black Redstart	16	1.646	16	-1.638	32
17	<i>Sylvia atricapilla</i>	Eurasian Blackcap	17	1.549	17	-1.535	35
18	<i>Phylloscopus collybita</i>	Common Chiffchaff	18	1.443	18	-1.419	38

	<i>scientific name</i>	english name	EFA with experts		EFA without experts		golden 50
			rank	z-value	rank	z-value	rank
19	<i>Troglodytes troglodytes</i>	Eurasian Wren	19	1.389	19	-1.344	21
20	<i>Carduelis carduelis</i>	European Goldfinch	20	1.386	20	-1.331	18
21	<i>Motacilla alba</i>	White Wagtail	21	1.382	21	-1.330	15
22	<i>Alauda arvensis</i>	Eurasian Skylark	22	1.359	22	-1.304	24
23	<i>Apus apus</i>	Common Swift	23	1.329	23	-1.273	29
24	<i>Hirundo rustica</i>	Barn Swallow	24	1.328	24	-1.262	16
25	<i>Garrulus glandarius</i>	Eurasian Jay	25	1.325	25	-1.261	6
26	<i>Emberiza citronella</i>	Yellowhammer	26	1.242	26	-1.179	36
27	<i>Ardea cinerea</i>	Grey Heron	27	1.218	27	-1.138	14
28	<i>Milvus milvus</i>	Red Kite	28	1.167	30	-1.066	28
29	<i>Columba livia f. domestica</i>	Feral Pigeon	29	1.15	29	-1.122	26
30	<i>Fulica atra</i>	Eurasian Coot	30	1.133	31	-1.044	40
31	<i>Falco tinnunculus</i>	Common Kestrel	31	1.124	32	-1.026	25
32	<i>Pyrrhula pyrrhula</i>	Eurasian Bullfinch	32	1.097	33	-1.001	22
33	<i>Delichon urbicum</i>	Common House Martin	33	1.057	34	-0.946	19
34	<i>Passer montanus</i>	Eurasian Tree sparrow	34	1.022	28	-1.123	
35	<i>Vanellus vanellus</i>	Northern Lapwing	35	0.942	37	-0.806	37
36	<i>Picus viridis</i>	European Green Woodpecker	36	0.921	38	-0.788	42
37	<i>Chroicocephalus ridibundus</i>	Black-headed Gull	37	0.883	39	-0.763	45
38	<i>Anser anser</i>	Greylag Goose	38	0.883	36	-0.823	20
39	<i>Cygnus olor</i>	Mute Swan	39	0.87	41	-0.733	9
40	<i>Podiceps cristatus</i>	Great Crested Grebe	40	0.803	44	-0.662	48
41	<i>Streptopelia decaocto</i>	Eurasian Collared Dove	41	0.777	42	-0.708	
42	<i>Ciconia Ciconia</i>	White Stork	42	0.702	49	-0.526	5
43	<i>Turdus philomelos</i>	Song Thrush	43	0.694	35	-0.835	47
44	<i>Coccothraustes coccothraustes</i>	Hawfinch	44	0.689	40	-0.748	
45	<i>Cuculus canorus</i>	Common Cuckoo	45	0.66	51	-0.487	27
46	<i>Phalacrocorax carbo</i>	Great Cormorant	46	0.657	50	-0.491	39

	<i>scientific name</i>	english name	EFA with experts		EFA without experts		golden 50	
			rank	z-value	rank	z-value	rank	rank
47	<i>Coleus monedula</i>	Eurasian Jackdaw	47	0.614	46	-0.589		41
48	<i>Phoenicurus phoenicurus</i>	Common Redstart	48	0.58	53	-0.459		
49	<i>Aegithalos caudatus</i>	Long-tailed Tit	49	0.576	47	-0.547		
50	<i>Turdus pilaris</i>	Fieldfare	50	0.573	52	-0.477		
51	<i>Certhia brachydactyla</i>	Short-toed Treecreeper	51	0.572	54	-0.401		
52	<i>Periparus ater</i>	Coal Tit	52	0.564	43	-0.690		
53	<i>Alcedo atthis</i>	Common Kingfisher	53	0.515	58	-0.307		30
54	<i>Accipiter nisus</i>	Eurasian Sparrowhawk	54	0.47	56	-0.348		
55	<i>Phasianus colchicus</i>	Common Pheasant	55	0.45	61	-0.261		46
56	<i>Regulus regulus</i>	Goldcrest	56	0.449	57	-0.332		
57	<i>Prunella modularis</i>	Duncock	57	0.431	48	-0.535		
58	<i>Aythya fuligula</i>	Tufted Duck	58	0.425	55	-0.367		
59	<i>Grus grus</i>	Common Crane	59	0.409	60	-0.266		43
60	<i>Poecile palustris</i>	Marsh Tit	60	0.386	45	-0.620		
61	<i>Gallinula chloropus</i>	Common Moorhen	61	0.357	62	-0.218		
62	<i>Acrocephalus scirpaceus</i>	Eurasian Reed Warbler	62	0.289	66	-0.148		
63	<i>Luscinia megarhynchos</i>	Common Nightingale	63	0.282	68	-0.129		44
64	<i>Corvus cornix</i>	Hooded Crow	64	0.154	67	-0.133		
65	<i>Alopochen aegyptiaca</i>	Egyptian Goose	65	0.117	82	-0.066		
66	<i>Larus argentatus</i>	European Herring Gull	66	0.107	70	-0.072		
67	<i>Corvus corax</i>	Common Raven	67	0.102	64	-0.210		49
68	<i>Strix aluco</i>	Tawny Owl	68	0.084	87	-0.172		
69	<i>Haematopus ostralegus</i>	Eurasian Oystercatcher	69	0.051	77	-0.006		
70	<i>Linaria cannabina</i>	Common Linnet	70	0.044	59	-0.289		
71	<i>Spinus pinus</i>	Eurasian Siskin	71	0.04	63	-0.217		
72	<i>Lophophanes cristatus</i>	Crested Tit	72	0.037	71	-0.066		
73	<i>Phylloscopus trochilus</i>	Willow Warbler	73	0.027	65	-0.205		
74	<i>Ardea alba</i>	Great White Egret	74	0.021	79	-0.033		

	<i>scientific name</i>	english name	EFA with experts		EFA without experts		golden 50	
			rank	z-value	rank	z-value	rank	rank
75	<i>Regulus ignicapilla</i>	Common Firecrest	75	0.013	78	-0.025		
76	<i>Emberiza schoeniclus</i>	Common Reed Bunting	76	-0.017	76	-0.011		
77	<i>Dryocopus martius</i>	Black Woodpecker	77	-0.031	84	-0.084		
78	<i>Serinus serinus</i>	European Serin	78	-0.059	72	-0.028		
79	<i>Fringilla montifringilla</i>	Brambling	79	-0.068	83	-0.067		
80	<i>Oriolus oriolus</i>	Eurasian Golden Oriole	80	-0.074	90	-0.219		
81	<i>Perdix perdix</i>	Grey Partridge	81	-0.079	93	-0.301		
82	<i>Lanius collurio</i>	Red-backed Shrike	82	-0.116	92	-0.256		
83	<i>Saxicola rubicola</i>	European Stonechat	83	-0.131	69	-0.083		
84	<i>Sylvia borin</i>	Garden Warbler	84	-0.133	75	-0.014		
85	<i>Tyto alba</i>	Barn Owl	85	-0.134		-0.432		
86	<i>Motacilla flava</i>	Western Yellow Wagtail	86	-0.139	86	-0.138		
87	<i>Branta canadensis</i>	Canada Goose	87	-0.168	88	-0.179		50
88	<i>Motacilla cinerea</i>	Grey Wagtail	88	-0.175	89	-0.179		
89	<i>Muscicapa striata</i>	Spotted Flycatcher	89	-0.19	73	-0.019		
90	<i>Corvus frugilegus</i>	Rook	90	-0.196	81	-0.060		
91	<i>Sylvia communis</i>	Common Whitethroat	91	-0.202	74	-0.015		
92	<i>Tachybaptus ruficollis</i>	Little Grebe	92	-0.224	94	-0.306		
93	<i>Sylvia curruca</i>	Lesser Whitethroat	93	-0.242	80	-0.039		
94	<i>Accipiter gentilis</i>	Northern Goshawk	94	-0.292	97	-0.393		
95	<i>Psittacula kramera</i>	Ring-necked Parakeet	95	-0.296		-0.618		
96	<i>Turdus viscivorus</i>	Mistle Thrush	96	-0.297	85	-0.096		
97	<i>Aythya ferina</i>	Common Pochard	97	-0.345		-0.453		
98	<i>Columba oenas</i>	Stock Dove	98	-0.409	91	-0.239		
99	<i>Cinclus cinclus</i>	White-throated Dipper	99	-0.425		-0.474		
100	<i>Upupa epops</i>	Eurasian Hoopoe	100	-0.462		-0.753		
101	<i>Bombus garrulus</i>	Bohemian Waxwing	101	-1.014		1.088		
102	<i>Caprimulgus europaeus</i>	Eurasian Nightjar	102	-1.237		1.347		

Liebe Teilnehmerinnen und Teilnehmer,

wir planen in der Biologie-Didaktik der Universität Tübingen eine groß angelegte Studie zum Thema Vogelartenkenntnis in der Allgemeinbevölkerung und in Schulen und möchten Sie gerne bitten, uns mit Ihrer Expertise zu unterstützen. Mit verschiedenen Methoden haben wir 102 Vogelarten Deutschlands ausgewählt. Diese wollen wir nun mit Ihrer Hilfe auf eine Anzahl von 30-50 Arten reduzieren. Die Einschätzung dauert etwa 10 Minuten und es gibt kein Richtig oder Falsch – Ihre Expertise zählt. Bitte geben Sie für die nachfolgenden Vogelarten an, ob diese Ihrer Meinung nach von der Allgemeinbevölkerung gekannt werden sollten, in einem dreistufigen Verfahren (ja, vielleicht, nein). Die Artnamen folgen Barthel & Krüger (2019). Ihre Daten werden vollkommen anonym und der DSGVO folgend gespeichert. Sie können die Umfrage jederzeit und ohne Konsequenzen beenden.

Vielen Dank,
Talia Härtel, Janina Vanhöfen & Christoph Randler

Sollten die nachfolgenden Vogelarten Ihrer Meinung nach von der Allgemeinbevölkerung gekannt werden?

	Ja	Vielleicht	Nein
Amsel (<i>Turdus merula</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Misteldrossel (<i>Turdus viscivorus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Singdrossel (<i>Turdus philomelos</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wacholderdrossel (<i>Turdus pilaris</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Blaumeise (<i>Cyanistes caeruleus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Haubenmeise (<i>Lophophanes cristatus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kohlmeise (<i>Parus major</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sumpfmeise (<i>Poecile palustris</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tannenmeise (<i>Periparus ater</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heckenbraunelle (<i>Prunella modularis</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Sollten die nachfolgenden Vogelarten Ihrer Meinung nach von der Allgemeinbevölkerung gekannt werden?

	Ja	Vielleicht	Nein
Bergfink (<i>Fringilla montifringilla</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bluthänfling (<i>Linaria cannabina</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Buchfink (<i>Fringilla coelebs</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Erlenzeisig (<i>Spinus spinus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gimpel/Dompfaff (<i>Pyrrhula pyrrhula</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Girlitz (<i>Serinus serinus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Grünfink/Grünling (<i>Chloris chloris</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kernbeißer (<i>Coccothraustes coccothraustes</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stieglitz/Distelfink (<i>Carduelis carduelis</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pirol (<i>Oriolus oriolus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Sollten die nachfolgenden Vogelarten Ihrer Meinung nach von der Allgemeinbevölkerung gekannt werden?

	Ja	Vielleicht	Nein
Bachstelze (<i>Motacilla alba</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bergstelze/Gebirgsstelze (<i>Motacilla cinerea</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Schafstelze (<i>Motacilla flava</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Dohle (<i>Coleus monedula</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eichelhäher (<i>Garrulus glandarius</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Elster (<i>Pica pica</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kolkrabe (<i>Corvus corax</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Nebelkrähe (<i>Corvus cornix</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rabenkrähe (<i>Corvus corone</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Saatkrähe (<i>Corvus frugilegus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Sollten die nachfolgenden Vogelarten Ihrer Meinung nach von der Allgemeinbevölkerung gekannt werden?

	Ja	Vielleicht	Nein
Gartenrotschwanz (<i>Phoenicurus phoenicurus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Grauschnäpper (<i>Muscicapa striata</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hausrotschwanz (<i>Phoenicurus ochruros</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Nachtigall (<i>Luscinia megarhynchos</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rotkehlchen (<i>Erithacus rubecula</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Schwarzkehlchen (<i>Saxicola rubicola</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Dorngrasmücke (<i>Sylvia communis</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gartengrasmücke (<i>Sylvia borin</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Klappergrasmücke (<i>Sylvia curruca</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mönchsgrasmücke (<i>Sylvia atricapilla</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Sollten die nachfolgenden Vogelarten Ihrer Meinung nach von der Allgemeinbevölkerung gekannt werden?

	Ja	Vielleicht	Nein
Teichrohrsänger (<i>Acrocephalus scirpaceus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feldlerche (<i>Alauda arvensis</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fitis (<i>Phylloscopus trochilus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Zilpzalp (<i>Phylloscopus collybita</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Goldammer (<i>Emberiza citrinella</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rohrhammer (<i>Emberiza schoeniclus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mehlschwalbe (<i>Delichon urbicum</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rauchschwalbe (<i>Hirundo rustica</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sommersgoldhähnchen (<i>Regulus ignicapilla</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wintersgoldhähnchen (<i>Regulus regulus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Sollten die nachfolgenden Vogelarten Ihrer Meinung nach von der Allgemeinbevölkerung gekannt werden?

	Ja	Vielleicht	Nein
Gartenbaumläufer (<i>Certhia brachydactyla</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feldsperling (<i>Passer montanus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Haussperling (<i>Passer domesticus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kleiber (<i>Sitta europaea</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Neuntöter/Rotrückenvürger (<i>Lanius collurio</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Schwanzmeise (<i>Aegithalos caudatus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Seidenschwanz (<i>Bombycilla garrulus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Star (<i>Sturnus vulgaris</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wasseramsel (<i>Cinclus cinclus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Zaunkönig (<i>Troglodytes troglodytes</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Sollten die nachfolgenden Vogelarten Ihrer Meinung nach von der Allgemeinbevölkerung gekannt werden?

	Ja	Vielleicht	Nein
Jagdfasan (<i>Phasianus colchicus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rebhuhn (<i>Perdix perdix</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Austernfischer (<i>Haematopus ostralegus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kiebitz (<i>Vanellus vanellus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lachmöwe (<i>Chroicocephalus ridibundus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Silbermöwe (<i>Larus argentatus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Habicht (<i>Accipiter gentilis</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mäusebussard (<i>Buteo buteo</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rotmilan (<i>Milvus milvus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sperber (<i>Accipiter nisus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Sollten die nachfolgenden Vogelarten Ihrer Meinung nach von der Allgemeinbevölkerung gekannt werden?

	Ja	Vielleicht	Nein
Graugans (<i>Anser anser</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Höckerschwan (<i>Cygnus olor</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kanadagans (<i>Branta canadensis</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Nilgans (<i>Alopochen aegyptiaca</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reiherente (<i>Aythya fuligula</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stockente (<i>Anas platyrhynchos</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tafelente (<i>Aythya ferina</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Turmfalke (<i>Falco tinnunculus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Graureiher (<i>Ardea cinerea</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Silberreiher (<i>Ardea alba</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Sollten die nachfolgenden Vogelarten Ihrer Meinung nach von der Allgemeinbevölkerung gekannt werden?

	Ja	Vielleicht	Nein
Buntspecht (<i>Dendrocopos major</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Grünspecht (<i>Picus viridis</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Schwarzspecht (<i>Dryocopus martius</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Haubentaucher (<i>Podiceps cristatus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Zwergtaucher (<i>Tachybaptus ruficollis</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Straßentaube (<i>Columba livia f. domestica</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hohltaube (<i>Columba oenas</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ringeltaube (<i>Columba palumbus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Türkentaube (<i>Streptopelia decaocto</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eisvogel (<i>Alcedo atthis</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Sollten die nachfolgenden Vogelarten Ihrer Meinung nach von der Allgemeinbevölkerung gekannt werden?

	Ja	Vielleicht	Nein
Schleiereule (<i>Tyto alba</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Waldkauz (<i>Strix aluco</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Weißstorch (<i>Ciconia ciconia</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Blässhuhn/Bläsralle (<i>Fulica atra</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kranich (<i>Grus grus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Teichhuhn/Teichralle (<i>Gallinula chloropus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kormoran (<i>Phalacrocorax carbo</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Halsbandsittich (<i>Psittacula krameri</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kuckuck (<i>Cuculus canorus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mauersegler (<i>Apus apus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wiedehopf (<i>Upupa epops</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ziegenmelker/Nachtschwalbe (<i>Caprimulgus europaeus</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Vielen Dank für Ihre Einschätzungen!

Falls Ihnen noch eine oder mehrere Arten einfallen, die Ihrer Meinung nach in der Vorauswahl gefehlt haben, können Sie diese im folgenden gerne noch angeben:

Bitte nehmen Sie sich noch kurz Zeit für ein paar Angaben zu Ihrer Person. Es sind 9 Fragen.

1. Bitte treffen Sie eine Aussage über Ihr Geschlecht.

- weiblich
- männlich
- divers
- ohne Angabe

2. Bitte geben Sie ihr Alter in Jahren an.

3. Was ist Ihr höchster Bildungsabschluss?

- kein Schulabschluss
- Grund-/Hauptschulabschluss
- Realschule (Mittlere Reife)
- Fachhochschulreife
- Gymnasium (Abitur)
- abgeschlossene Ausbildung
- Fachhochschulabschluss
- Hochschule (Diplom)
- Hochschule (Magister)
- Hochschule (Staatsexamen)
- Hochschule (Bachelor)
- Hochschule (Master)
- Hochschule (Promotion)
- Hochschule (Habilitation)
- Andere (bitte angeben):

**4. Welche der folgenden Bezeichnungen trifft am ehesten auf Sie zu?
Mehrfachnennungen sind möglich.**

- Schüler/Schülerin
- Student/Studentin
- Lehrperson an einer Universität/Hochschule
- Lehrperson an einer Schule
- Lehrperson im nicht-schulischen (informellen) Bereich
- Mitglied in einem Naturschutzverband oder einer ornithologischen Arbeitsgemeinschaft
- angestellt/verbeamtet in einer Naturschutzbehörde (i.w.S.)
- Gutachter/Gutachterin für Ornitho und/oder eBird
- Vogelbeobachter/Vogelbeobachterin
- überwiegend in Wissenschaft/Forschung tätig
- Sonstiges (bitte angeben):

5. Wie viele Vogelarten können Sie selbst am Aussehen erkennen (ohne Buch oder App)?

- bis zu 25
- 26-45
- 46-100
- 101-250
- 251-500
- über 500

6. Wie viele Vogelarten können Sie am Gesang erkennen?

- bis zu 5
- 6-10
- 11-25
- 26-80
- 81-150
- über 150

7. Bitte schätzen Sie Ihre ornithologischen Fähigkeiten ein.

Anfänger/Anfängerin



Experte/Expertin

**8. Wie viele Vogelexkursionen machen Sie etwa pro Jahr (mindestens 2 km von Ihrem Zuhause entfernt und ausgenommen der Jahre mit COVID-19-Restriktionen)?**

- keine
- 1-2
- 3-10
- 11-35
- über 35

9. Bitte geben Sie eine ungefähre Anzahl von Tagen an, an denen Sie im letzten Jahr Vögel beobachtet haben. Hiervon sind Zufallsbeobachtungen und die Zeit während der COVID-19-Restriktionen ausgenommen.

- keine
- 10
- 11-30
- 31-70
- 71-200
- über 200

Vielen herzlichen Dank für Ihre Teilnahme!

Falls Sie noch weitere Experten und Expertinnen kennen, die Sie für geeignet halten und die Interesse an diesem Ranking haben könnten, dürfen Sie uns gerne informieren (unter: [\[REDACTED\]](#)) oder auch den Link weiterleiten.

Ihre Antworten wurden gespeichert, Sie können das Browser-Fenster nun schließen.

Liebe Teilnehmerinnen und Teilnehmer,

wir führen in der Biologie-Didaktik der Universität Tübingen eine groß angelegte Studie zum Thema **Vogelartenkenntnis** in der Bevölkerung durch und würden uns sehr über Ihre Unterstützung freuen! Im Folgenden werden Ihnen zunächst Fragen zu Ihrer Person, Ihren Interessen und Einstellungen gestellt und anschließend Fotos von 50 Vogelarten gezeigt, die Sie bestimmen sollen.

Für die Umfrage sollten Sie ca. **15-25 Minuten** einplanen.

Ihre Daten werden vollkommen anonym und der DSGVO folgend gespeichert. Sie können die Umfrage jederzeit und ohne Konsequenzen beenden.

1. Bitte geben Sie Ihr Alter in Jahren an.**2. Bitte geben Sie Ihr Geschlecht an.**

- männlich
- weiblich
- divers

3. Bitte nennen Sie die Postleitzahl Ihres Hauptwohnsitzes.

bei Studierenden: bitte Postleitzahl des Heimatwohnsitzes angeben.

4. Wie oft halten Sie sich in einem Garten auf?

- täglich
- mehrmals wöchentlich
- einmal wöchentlich
- monatlich
- selten

5. Wie weit ist die nächste Grünfläche entfernt, die Sie regelmäßig aufsuchen?

- bis 1 km
- 1-2 km
- 3-5 km
- 6-10 km
- über 10 km

Bitte geben Sie an, was auf Sie zutrifft:

Ich bin...

- Student / Studentin
- berufstätig
- derzeit ohne Festanstellung
- in Rente
- sonstiges:

Hat Ihr Studienfach einen biologischen Bezug?

- ja
- nein

Bitte nennen Sie uns Ihren Studienort.

Bitte nennen Sie uns Ihren angestrebten Studienabschluss.

Bitte nennen Sie Ihren Beruf.

Bitte geben Sie Ihren höchsten Abschluss an.

Bitte geben Sie an, inwieweit die folgenden Aussagen auf Sie zutreffen:

	trifft überhaupt nicht zu	trifft eher nicht zu	teils/teils	trifft eher zu	trifft vollkommen zu
Ich interessiere mich für Vogelkunde.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Das Thema Vögel ist mir wichtig.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Vögel faszinieren mich.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Bitte geben Sie an, inwieweit die folgenden Aussagen auf Sie zutreffen:

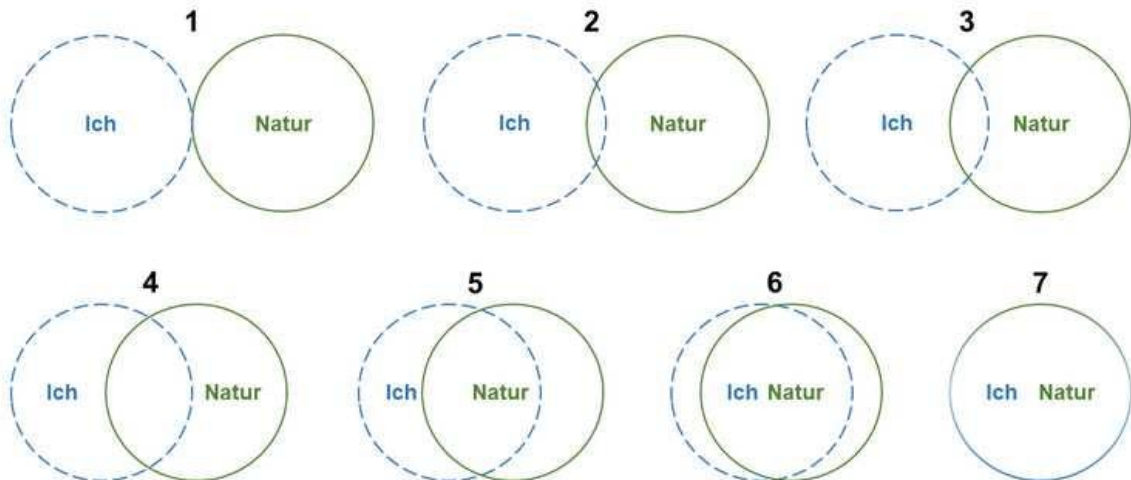
Ich mag Vögel, weil sie...

	trifft überhaupt nicht zu	trifft eher nicht zu	teils/ teils	trifft eher zu	trifft vollkommen zu
...schön anzusehen sind.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...einen angenehmen Gesang haben.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...mir helfen, mich besser zu fühlen.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Wie viele Vogelarten können Sie selbst am Aussehen erkennen (ohne Buch oder App)?

- bis zu 5
- 6-10
- 11-25
- 26-45
- 46-100
- 101-250
- 251-500
- über 500

Bitte wählen Sie aus, welche Nummer Ihrer Verbindung zur Natur entspricht.



[Bitte auswählen] ▾

Bitte geben Sie an, inwieweit die folgenden Aussagen auf Sie zutreffen:

	trifft überhaupt nicht zu	trifft eher nicht zu	teils/teils	trifft eher zu	trifft vollkommen zu
Ich fühle mich entspannt, wenn ich die Vögel in meinem Garten beobachte.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wenn ich einen bestimmten Vogel, ein bestimmtes Individuum erkenne, fühle ich mich diesem besonders verbunden.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wenn ich Vögel im Garten beobachte, fühle ich mich mit der Natur verbunden.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Bitte geben Sie an, inwieweit die folgenden Aussagen auf Sie zutreffen:

	trifft überhaupt nicht zu	trifft eher nicht zu	teils/ teils	trifft eher zu	trifft vollkommen zu
Tiere und Pflanzen existieren in erster Linie zum Nutzen der Menschen.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Es macht mir großen Spaß, selbst ins Grüne (Wald, Wiese) hinauszugehen.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ich sitze gerne am Rande eines Weihers und betrachte bzw. beobachte dabei die Natur.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Der Mensch soll über die Natur herrschen.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ich fühle mich wohl in der Stille der Natur.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Menschen sind wichtiger als die anderen Lebewesen.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Bitte geben Sie an, wie häufig Sie die folgenden Aktivitäten durchführen:

	nie	selten	gelegentlich	oft	sehr häufig
Ich gehe in die Natur, um Tiere zu beobachten.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ich gehe in den Zoo / das Naturkundemuseum.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ich stelle Nistkästen für Vögel auf.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	nie	unregelmäßig	regelmäßig im Winter	das ganze Jahr über
Ich füttere Vögel in meinem Garten / auf meinem Balkon.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Was ist die Quelle Ihrer Kenntnis über Vögel? Bitte kreuzen Sie an, was auf Sie zutrifft.

Personen:	eher ja	eher nein
Lehrpersonen an Schule, Hochschule oder Universität.	<input type="radio"/>	<input type="radio"/>
Lehrpersonen außerhalb der Schule (z.B. Exkursionsleiter:innen bei Naturschutzorganisationen etc.).	<input type="radio"/>	<input type="radio"/>
Eltern, Großeltern.	<input type="radio"/>	<input type="radio"/>
Freunde, Bekannte.	<input type="radio"/>	<input type="radio"/>

Medien:	eher ja	eher nein
Bücher	<input type="radio"/>	<input type="radio"/>
Dokumentationen (TV / Streaming-Dienste / DVD oder Blu-ray)	<input type="radio"/>	<input type="radio"/>
Internet	<input type="radio"/>	<input type="radio"/>
Soziale Medien	<input type="radio"/>	<input type="radio"/>

In diesem Teil werden Ihnen Fragen bezüglich Ihrer Artenkenntnis gestellt. Dabei beschreibt die Artenkenntnis in dieser Studie das Erkennen und Benennen von Vogelarten. Eine Art ist dabei die Grundeinheit der Taxonomie, beispielsweise ist der Braunbär eine Art innerhalb der Familie der Bären.

Bitte geben Sie immer den deutschen Namen für die jeweilige Vogelart an.

Beispiel für eine korrekte Benennung einer Vogelart:

Bitte benennen Sie die abgebildete Vogelart so genau wie möglich.



korrekte Antwort: **Kolibbenente**

Bitte benennen Sie die abgebildete Vogelart so genau wie möglich.



-
- kann ich nicht benennen.

Bitte benennen Sie die abgebildete Vogelart so genau wie möglich.



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- kann ich nicht benennen.

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-
- kann ich nicht benennen.

Bitte benennen Sie die abgebildete Vogelart so genau wie möglich.



kann ich nicht benennen.

Bitte benennen Sie die abgebildete Vogelart so genau wie möglich.



kann ich nicht benennen.

Bitte benennen Sie die abgebildete Vogelart so genau wie möglich.



kann ich nicht benennen.

Vielen herzlichen Dank für Ihre Teilnahme!

Falls Sie noch weitere Personen kennen, die gerne an dieser Studie teilnehmen würden, dürfen Sie gerne den Link weiterleiten.

Bei weiteren Fragen melden Sie sich gerne bei [REDACTED]

Ihre Antworten wurden gespeichert, Sie können das Browser-Fenster nun schließen.

Liebe Teilnehmerin / Lieber Teilnehmer,

in diesem Fragebogen werden Dir zunächst Fragen zu Deiner Person und Deinen Interessen und Freizeitaktivitäten gestellt. Im Anschluss werden Dir 30 Bilder von Vogelarten gezeigt, die Du benennen sollst. Bitte achte darauf, alle Fragen zu beantworten und Dir die Fragestellung gut durchzulesen. Viel Spaß beim Ausfüllen!

1. Bitte gib Dein Alter in Jahren an.

2. Bitte gib Dein Geschlecht an.

- männlich
- weiblich
- divers

3. Bitte nenne die Postleitzahl Deines Wohnortes oder falls Du diese nicht weißt, den Namen Deines Wohnortes.






4. Wie oft hältst du Dich in einem Garten auf?

- täglich
- mehrmals wöchentlich
- einmal wöchentlich
- monatlich
- selten






5. Wie weit ist die nächste Grünfläche entfernt, die Du regelmäßig aufsuchst?

- weniger als 1 km
- 1-3 km
- 3-10 km
- über 10 km

6. Bitte gib an, inwieweit die folgenden Aussagen auf Dich zutreffen:

	trifft überhaupt nicht zu 	trifft eher nicht zu 	teils/ teils 	trifft eher zu 	trifft vollkommen zu 
	1	2	3	4	5
Ich interessiere mich für Vogelkunde.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Das Thema Vögel ist mir wichtig.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Vögel faszinieren mich.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7. Bitte gib an, inwieweit die folgenden Aussagen auf Dich zutreffen:

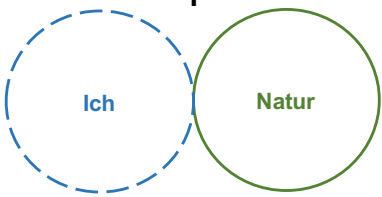
Ich mag Vögel, weil sie...	trifft überhaupt nicht zu	trifft eher nicht zu	teils/ teils	trifft eher zu	trifft vollkommen zu
					
	1	2	3	4	5
...schön anzusehen sind.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...einen angenehmen Gesang haben.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...mir helfen, mich besser zu fühlen.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

8. Wie viele Vogelarten kannst Du selbst am Aussehen erkennen (ohne Buch oder App)?

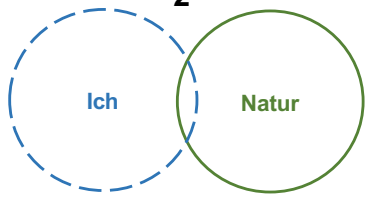
- bis zu 5
- 6-10
- 11-25
- 26-45
- 46-100

9. Bitte kreuze an, welches Bild am ehesten auf Deine Verbindung zur Natur zutrifft.

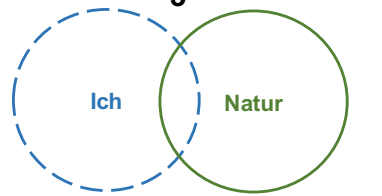
1



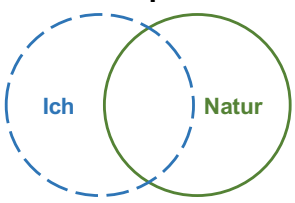
2



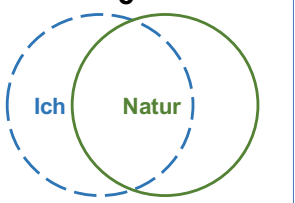
3



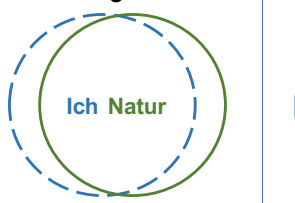
4




5








6








7



10. Bitte gib an, inwieweit die folgenden Aussagen auf Dich zutreffen:

	trifft überhaupt nicht zu 	trifft eher nicht zu 	teils/ teils 	trifft eher zu 	trifft vollkommen zu 
	1	2	3	4	5
Ich fühle mich entspannt, wenn ich die Vögel in meinem Garten beobachte.	[]	[]	[]	[]	[]
Wenn ich einen bestimmten Vogel, ein bestimmtes Individuum erkenne, fühle ich mich diesem besonders verbunden.	[]	[]	[]	[]	[]
Wenn ich Vögel im Garten beobachte, fühle ich mich mit der Natur verbunden.	[]	[]	[]	[]	[]

11. Bitte gib an, inwieweit die folgenden Aussagen auf Dich zutreffen:

	trifft überhaupt nicht zu 	trifft eher nicht zu 	teils/ teils 	trifft eher zu 	trifft vollkommen zu 
	1	2	3	4	5
Tiere und Pflanzen existieren in erster Linie zum Nutzen der Menschen.	[]	[]	[]	[]	[]
Es macht mir großen Spaß, selbst ins Grüne (Wald, Wiese) hinauszugehen.	[]	[]	[]	[]	[]
Ich sitze gerne am Rande eines Weihers und betrachte bzw. beobachte dabei die Natur.	[]	[]	[]	[]	[]
Der Mensch soll über die Natur herrschen.	[]	[]	[]	[]	[]
Ich fühle mich wohl in der Stille der Natur.	[]	[]	[]	[]	[]
Menschen sind wichtiger als die anderen Lebewesen.	[]	[]	[]	[]	[]

12. Bitte gib an, wie häufig Du die folgenden Aktivitäten durchführst:

Ich gehe in die Natur, um Tiere zu beobachten.

nie				sehr häufig
[1]	[2]	[3]	[4]	[5]

Ich gehe in den Zoo / das Naturkundemuseum.

nie				sehr häufig
[1]	[2]	[3]	[4]	[5]

Ich hänge Nistkästen für Vögel auf.

nie				sehr häufig
[1]	[2]	[3]	[4]	[5]

Ich füttere Vögel in meinem Garten / auf meinem Balkon.

nie	unregelmäßig	regelmäßig im Winter	das ganze Jahr über
[1]	[2]	[3]	[4]

13. Woher kommt Deine Kenntnis über Vögel? Bitte kreuze an, was auf Dich zutrifft.

Personen:	ja	nein
a. Lehrpersonen	[]	[]
b. Lehrpersonen außerhalb der Schule (z.B. Exkursionsleiter:innen bei Naturschutzorganisationen etc.)	[]	[]
c. Eltern, Großeltern	[]	[]
d. Freunde, Bekannte	[]	[]
Medien:		
a. Bücher	[]	[]
b. Dokumentationen (TV / Streaming-Dienste / DVD oder Blueray)	[]	[]
c. Internet	[]	[]
d. Soziale Medien	[]	[]

In diesem Teil werden Dir Fragen zu Deiner Artenkenntnis gestellt. Denke daran, die abgebildeten Vögel so genau wie möglich zu benennen! Würdest Du im Fragebogen bspw. einen Bären erkennen, solltest Du genauer angeben, ob es sich dabei um einen Braunbären handelt oder vielleicht um einen Eisbären. Auch die Angabe „Wal“ würde bei einem Wal-Bild nicht die volle Punktzahl geben, da genauer genannt werden müsste, ob es sich um einen Blauwal, einen Buckelwal oder eine andere Walart handelt.

Beispiel für eine korrekte Benennung einer Vogelart:

Bitte benenne die abgebildete Vogelart so genau wie möglich.



Antwort: Kolbenente (Nur Ente ist keine vollständige Antwort).

Bitte benenne die abgebildete Vogelart so genau wie möglich.



 kann ich nicht benennen



 kann ich nicht benennen



 kann ich nicht benennen



 kann ich nicht benennen



 kann ich nicht benennen



 kann ich nicht benennen

Bitte benenne die abgebildete Vogelart so genau wie möglich.



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen

Bitte benenne die abgebildete Vogelart so genau wie möglich.



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen

Bitte benenne die abgebildete Vogelart so genau wie möglich.



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen

Bitte benenne die abgebildete Vogelart so genau wie möglich.



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen



- _____
- kann ich nicht benennen

Vielen Dank für Deine Teilnahme!