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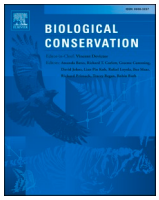

Attitudes of wildlife park visitors towards returning wildlife species: An analysis of patterns and correlates

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ABSTRACT

Understanding which variables mediate people's attitudes towards wildlife species is fundamental for improving human-wildlife coexistence in increasingly human-dominated landscapes. Based on questionnaire responses (a total of $n = 589$ responses, of which $n = 459$ were complete and used for statistical analysis), we investigated the attitudes of visitors to two wildlife parks located in different states of Germany towards three returning wildlife species: European bison (*Bison bonasus*), moose (*Alces alces*) and grey wolf (*Canis lupus*). We used a principal component analysis (PCA) and summarized responses to 13 questions pertaining to attitudes towards each species. Using the loadings of the first dimension of each species-specific PCA as the response variable, we fitted generalized linear models to assess how sociodemographic background and formal knowledge influenced people's attitudes. Our comparative, multi-species approach revealed the presence of both species-specific and universal factors influencing attitudes towards wildlife species. Respondents' gender, exposure, and negative experiences with a target species all had varying effects across species-specific models. Effects of age, residential context, and knowledge of wildlife were relatively consistent for all three species. Older visitors (≥60 years of age) had more negative attitudes compared to other age groups; positive attitudes were more prevalent in respondents residing in urban areas while negative attitudes were linked to people residing in rural areas, and higher knowledge of wildlife species was associated with more positive attitudes. While all species-specific models explained relatively small amounts of the observed variation in people's attitudes to these iconic wildlife species, our findings provide quantitative evidence that enhancing people's knowledge about wildlife could be a key strategy for improving attitudes towards wildlife. Hence, environmental education programs and outreach activities are likely a crucial first step towards creating awareness, ultimately contributing to more sustainable human-nature relationships.

1. Introduction

A fundamental challenge for ensuring a sustainable future is to manage the coexistence of wildlife and humans in shared landscapes (Carter and Linnell, 2016; Kansky et al., 2021). Across the globe, landscapes have become increasingly human-dominated (Kremen and Merenlender, 2018), resulting in diverse interactions between people and wildlife (Pooley et al., 2017; König et al., 2021). From an anthropocentric perspective, negative interactions – so called "Human-wildlife conflicts (HWCs)" – are often highlighted (Madden, 2004; Lozano et al., 2019). While the term HWC gives the impression that the conflict is confined to humans and wildlife (Peterson et al., 2010), HWC often extends to social conflicts, which include a wide range of conflicts between humans with different opinions, values and cultural backgrounds

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(Redpath et al., 2013). In many circumstances, opposing attitudes towards wildlife species, and different preferences for wildlife management approaches or conservation targets can result in broader social conflicts between different societal groups (Redpath et al., 2013; Kansky and Knight, 2014; Carter and Linnell, 2016; Hill et al., 2017; Zimmermann et al., 2020). For example, the recent return of grey wolves in Germany was described as a success story by conservationists, whereas livestock farmers and hunter associations often do not support wolf conservation efforts, calling to relax its conservation status and demanding lethal control of wolves (Kiffner et al., 2019).

Human attitudes and behaviours are an essential part of HWC (Ostermann-Miyashita et al., 2021), but also the key to reducing and mediating negative human-wildlife interactions. It is therefore pivotal to understand human attitudes towards wildlife (Nyhus and Tilson, 2004). Put simply, effective coexistence policies can only be developed if we understand what factors increase or inhibit peoples' willingness to coexist with wild animals (Kansky et al., 2020; Kaltenborn and Linnell, 2022). Such an understanding is particularly important for large wildlife species that are now expanding their range, potentially interacting with people that previously had no or little direct exposure to them. In central Europe, the European bison (*Bison bonasus*), moose (*Alces alces*) and grey wolf (*Canis lupus*: hereafter referred to as "wolf") are currently expanding their range to areas where they had previously been extinct for centuries (Chapron et al., 2014; Corlatti and Zachos, 2022).

Due to habitat loss and unsustainable legal and illegal hunting, European bison were driven to extinction in the wild in the early 20th century (Pucek, 2004; Olech and Prezanowski, 2022). Based on a small captive population, a reintroduction program was launched after World War II (Olech and Perzanowski, 2016). Since then, the population of free ranging European bison has steadily increased, especially in Poland and Belarus (Olech and Perzanowski, 2016). Currently, approx. 340 wild European bison live in western Poland (Racynski and Bolbot, 2021). In 2017, one individual of this subpopulation crossed the border into Germany and was killed by a hunter according to the local authorities' decision. Retrospectively, this action was declared illegal (MLUK, 2020). Currently, Germany has one free-ranging European bison herd in the "Rothaargebirge", located in the central-western part of the country. This herd was released in 2013; conflict surrounding the management of this fee-ranging European bison herd is occasionally covered by the media (Schmitz et al., 2015).

Moose were eradicated in Germany during the 17th Century, and the central European population dropped to its lowest abundance in the early 20th century (Niedziałkowska, 2017). When the remaining population in Poland (one of the main strongholds of the species in Central Europe) drastically decreased in the 1990s, a hunting ban was imposed across the country (Borowik et al., 2021), which allowed the population to recover (Borowik et al., 2018). In the 20th century, none of the multiple attempts to actively re-establish a moose population in Germany was successful (Schönfeld, 2009). More recently, however, the frequency of moose sightings has increased in the eastern part of Germany (Martin, 2013; Janik et al., 2021). One male moose which had crossed the German-Polish border in 2018 currently occupies an area south of Berlin; its presence and behaviour is occasionally covered in the local media (Gandl, 2020).

In the Middle Ages, grey wolves were widespread across the European continent (Hindrikson et al., 2017), but large-scale eradication and persecution drove the population to an all-time low in the 1960s (Reinhardt et al., 2019). The reversal of this trend was facilitated by several international and European legal instruments agreed upon in the 1980s and the 1990s, such as the Bern Convention and the Habitats Directive for the conservation and protection of large carnivores (among other species) in Europe (Trouwborst, 2018). After their eradication during the 19th century, wolves started returning to Germany from Poland in the 1990s. Following the exponential population growth in neighbouring West Poland and subsequent dispersal, the first successful wolf reproduction within Germany was documented in 2000 (Nowak and Mysłajek, 2016). Since then, the population has been increasing at an annual growth rate of around 36 % (Hindrikson et al., 2017; Reinhardt et al., 2019).

Human societies may exhibit mixed emotions when faced with the return of large mammals to formerly occupied habitats (Chapron et al., 2014). While some people appreciate the successful conservation and recovery of these species (Arbieu et al., 2019; Carpio et al., 2020; Schwerk et al., 2021), others express severe concern over potential or actual problematic interactions associated with these species (Bergqvist et al., 2003; Klich et al., 2018; Dziki-Michalska et al., 2019; Klich et al., 2021). In the context of Germany, potential problematic interactions between humans and the two large herbivores include collisions with vehicles and trains, as well as browsing and bark damage in forests or crop damage (especially for European bison) in fields (Jasińska et al., 2019; Borowik et al., 2021; Nieszała et al., 2022). The increase in the wolf population brought with it significant increases in livestock losses through predation and provoked heated and emotional debates (Ronnenberg et al., 2017; Trouwborst, 2018; Kiffner et al., 2019; Reinhardt et al., 2019). Additionally, such concerns are possibly affected by the negative historical stigma of the grey wolf (Jürgens and Hackett, 2017).

Among the different parameters of human-nature relationships (Lehnen et al., 2022), scholars often focus on "attitudes", especially in the field of human-wildlife coexistence (Knox et al., 2021). Attitudes are the basis for tolerance and acceptance of wildlife and are typically correlated with behavioural intentions (Fulton et al., 1996; Bruskotter and Wilson, 2014; Carlson et al., 2022).

Studies on human attitudes towards wildlife often suggest strong site- and species-specificity. To identify general patterns of variables underlying the observed variation in attitudes towards wildlife species, Kansky and Knight conducted a systematic literature review (Kansky and Knight, 2014). According to this seminal review, key influential variables include the species identity, knowledge about the target species, exposure to and experience with the target species, and socio-demographic variables.

Some species are perceived as more "likeable" than others (Liordos et al., 2020) and human preference for various species is an important factor affecting attitudes towards wildlife. This sometimes influences conservation management (Clucas et al., 2008; Morse-Jones et al., 2012; Jarić et al., 2020): people are more willing to donate to conservation activities for "charismatic" species rather than those with a more severe conservation status (Colléony et al., 2017). The factors influencing species preference are complex (Kansky et al., 2016), but the local historical background often plays an important role (Cretois et al., 2021).

Although some research has been conducted on how general environmental knowledge affects an individual's conservation behaviour (Bonney et al., 2016; Haywood et al., 2016), few studies have focussed on the relationships between knowledge about a specific species and the attitudes towards it. Indeed, among the reviewed articles, only 6 % of the publications tested for the effects of knowledge on peoples' attitudes (Kansky and Knight, 2014). However, whenever knowledge was considered as an explanatory variable, it was consistently and positively correlated with attitudes towards endangered wildlife (Balasubramaniam et al., 2021; Bruckermann et al., 2021; Ren et al., 2022).

Exposure to and experience with a specific species was also a common variable in studies which focussed on human attitudes towards wildlife species (Kansky and Knight, 2014). Although many human-wildlife interactions occur in cities and areas with a high human footprint (Mueller et al., 2019; Tucker et al., 2020), numerous human-wildlife interactions with direct consequences for individual livelihoods (e.g. crop damages or livestock predation) occur in rural areas (Kleiven et al., 2004; Dickman, 2010; König et al., 2020; Ostermann-Miyashita et al., 2021). As human-wildlife interactions in rural settings are more likely to have direct effects on people's livelihoods, rural residents tend to have a lower tolerance towards wildlife compared to people residing in urban areas (Bandara and Tisdell, 2002; Dickman, 2010; Arbieu et al., 2019; König et al., 2021). Irrespective of the

residential context, personal experience with nature can have a long-lasting effect on an individual's attitude towards environmental and conservation topics (Ngo et al., 2019). In the context of human-wildlife interactions, both positive (e.g. watching wildlife in the landscape) and negative experiences (physical or economic damage caused by wildlife) with wild animals can affect the attitude of an individual towards the species (Arbieu et al., 2019; Lehnen et al., 2022).

Studies on human perceptions of wildlife ideally evaluate the effect of an individual's sociodemographic background such as formal education, gender, age, profession and income, on their attitudes towards wildlife (Kansky and Knight, 2014). Particularly, "gender" and "age" are frequently highlighted in the context of HWC (Morar and Peterlicean, 2012; George et al., 2016; Allendorf et al., 2017). Gender differences in the perception of wildlife species can mediate attitudes towards these species (Ogra, 2008; Gore and Kahler, 2012; Allendorf et al., 2017), which is important information when developing target group-specific awareness campaigns about wildlife (Hermann et al., 2013). Age can also be a major factor influencing perceptions and attitudes towards wildlife, as many studies have suggested that the younger generations currently display a greater interest in conservation and also are more willing to take action for a sustainable environment (Athihirunwong et al., 2018; Shafiei and Maleksaeidi, 2020; Haugestad et al., 2021). As a case in point, public attitudes towards wildlife species in the US have significantly improved from 1978 to 2014, especially for species which were historically stigmatized (George et al., 2016).

In this study, we aim to better understand attitudes and drivers of attitudes towards three returning mammal species in Germany: European bison, moose and wolf. Following Kansky and Knight (2014), we conducted a paper-based questionnaire in two wildlife parks in the federal states of Brandenburg and Lower Saxony to investigate the key influencing variables of the species identity, knowledge about the target species, exposure to and experience with the target species, and socio-demographic background. Our main objectives were to 1) assess the attitudes of visitors towards the three returning wildlife species and 2) identify which of the variables mediated attitudes towards each target species.

2. Materials and methods

2.1. Questionnaire development

To assess attitudes and associated drivers towards the target species, we conducted a questionnaire survey in two wildlife parks of Germany: Wildpark Schorfheide (hereafter referred to as "Schorfheide"), located in Brandenburg state, and Wisentgehege Springe (hereafter referred to as "Springe") which is located in Lower Saxony. We chose these two parks because the history of recolonization and the relative abundance of the three target species differ in each location. Brandenburg State (where Schorfheide is located) hosts the highest number of wolf territories in Germany (Reinhardt et al., 2019) and is a hotspot for moose sightings as well. Lower Saxony (where Springe is located), also has an established wolf population but moose do not occur here at the moment.

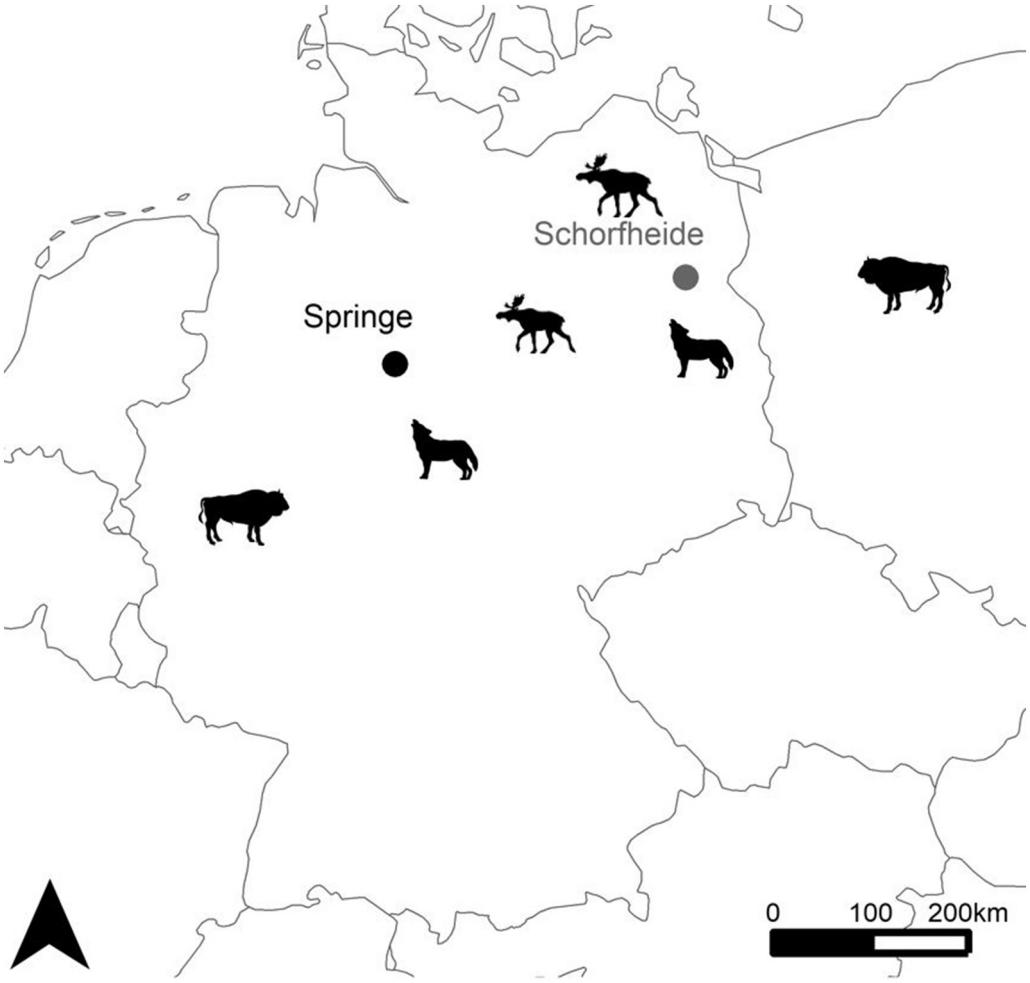

Fig. 1. Outline of Germany, showing the location of the two wildlife parks "Springe" and "Schorfheide". The animal silhouettes indicate the broad distribution of the three returning wildlife species (European bison, moose, and wolf) in relation to the wildlife parks.

Currently, neither of the two states has free-ranging European bison. However, free-ranging European bison occur east of Schorfheide (in western Poland) and southwest of Springe (in the "Rothaargebirge" located in the states of North Rhine-Westphalia and Hesse) (Fig. 1).

The questionnaire was developed based on the study by Arbieu et al. (2019), which assessed effects of experience and sociodemographic variables on attitudes towards the returning wolf in Germany. Before the survey, the survey protocol was reviewed within the working group (five members), as well as with three experts who had conducted structured questionnaire surveys with citizens previously. After the review process, we conducted three rounds of pre-testing. During each round, 5 to 10 participants, recruited from the non-scientific staff at the institute, filled out the questionnaire. Based on solicited feedback, we adjusted explanations, added illustrations and reformulated questions, to make the questionnaire engaging and comprehensive for participants at the wildlife parks. The institutes' review board for data protection and research ethics approved the questionnaire after detailed examination based on the EU General Data Protection Regulation on October 2nd 2020 (no reference number applied).

During four consecutive days of the autumn school holidays in October 2020, we asked visitors in each wildlife park to voluntarily participate in our survey. We handed out the printed questionnaires near the entrance and asked visitors to return them before leaving the park. Participants were given the option to either complete the questionnaire on the spot or over the course of their visit. An explanation about data handling based on the EU privacy policy (i.e. anonymous data processing) and a statement of the minimum age for participation (≥18 years of age) were placed on the top of the questionnaire. Only those questionnaires where participants ticked the "agree" box were analysed.

We conducted the subsequent analyses with a total of 589 surveys (Springe = 268, Schorfheide = 321) after removing those with an answer rate of <10 % (Springe = 1.8 %, Schorfheide = 0 %) (Fig. 2). The questionnaire consisted of five sections and a total of 97 multiple-choice questions (Fig. S1). For this study, we analysed the following four sections: (1) "perceptions and attitudes towards the species" (section A), (2) "animal quiz" focussing on the knowledge about the three target species (section B), (3) "exposure and experience" (section C), and (4) the "sociodemographic background" (section D) (Table 1).

2.2. Statistical analysis

We conducted all statistical analyses using R 4.1.3 (RCoreTeam, 2020). After defining unanswered, unclear, and single-answer questions where participants had selected multiple answers as "invalid", we first

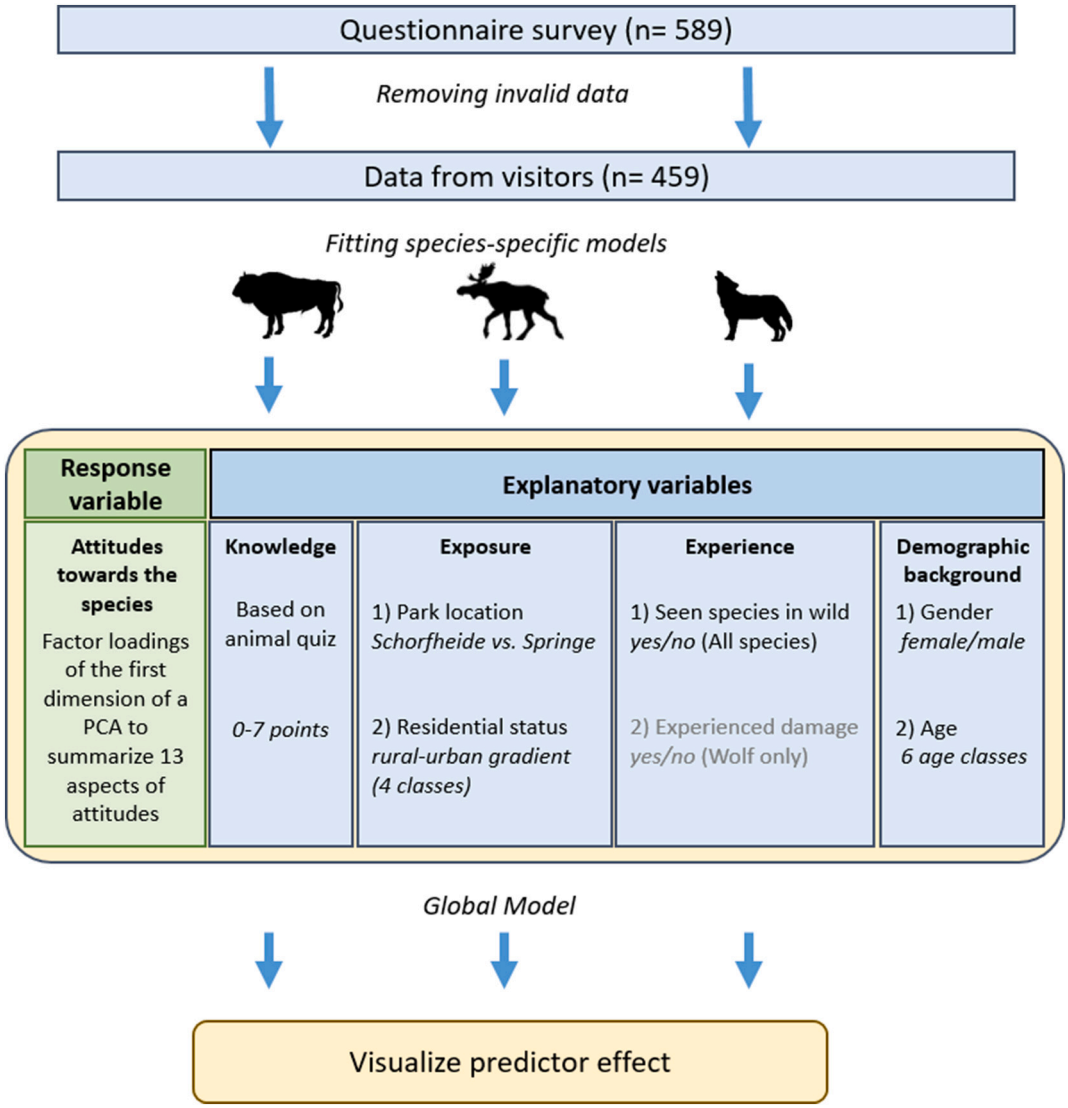

Fig. 2. Flowchart of the statistical analysis to identify correlates for attitudes towards European bison (*Bison bonasus*), moose (*Alces alces*) and wolves (*Canis lupus*) among visitors to two wildlife parks in Germany.

Table 1
The sociodemographic background of the interviewees in the wildlife parks Springe and Schorfheide.

	Schorfheide	Springe	Total
Number of participants	321	268	589
Number of visitors from the state in which the wildlife park is located in (Berlin and Brandenburg state for Schorfheide and Lower Saxony for Springe)	261 (81.3 %)	244 (91.0 %)	505 (85.7 %)
Gender			
Female	172 (53.6 %)	149 (55.6 %)	321 (54.4 %)
Male	120 (37.4 %)	92 (34.3 %)	212 (36.0 %)
Diverse	1 (0.3 %)	1 (0.4 %)	2 (0.3 %)
Invalid responses	28 (8.7 %)	26 (9.7 %)	54 (9.2 %)
Age			
18 to 24	16 (5.0 %)	39 (14.6 %)	55 (9.3 %)
25 to 29	25 (7.8 %)	19 (7.1 %)	44 (7.5 %)
30 to 39	79 (24.6 %)	47 (17.5 %)	126 (21.4 %)
40 to 49	81 (25.3 %)	66 (24.6 %)	147 (25.0 %)
50 to 59	62 (19.3 %)	34 (12.7 %)	96 (16.3 %)
≥60	34 (10.6 %)	35 (13.6 %)	69 (11.7 %)
Invalid responses	24 (7.5 %)	28 (10.4 %)	52 (8.8 %)
Residential status			
Urban	156 (48.6 %)	50 (18.6 %)	206 (35.0 %)
Rather urban	52 (16.2 %)	32 (11.9 %)	84 (14.3 %)
Rather rural	54 (16.8 %)	73 (27.2 %)	127 (21.6 %)
Rural	36 (11.2 %)	92 (34.3 %)	128 (21.7 %)
Invalid responses	23 (7.1 %)	21 (7.8 %)	44 (7.5 %)

conducted descriptive statistics (focussing on proportional data to allow comparability between groups). To identify correlates for attitudes towards the species, we followed a species-specific modelling approach. Prior to modelling, we excluded all cases in which one or more relevant variables were invalid (Fig. 2). Therefore, the models are based on $n = 459$ cases.

Attitudes – the response variable in this study – are multidimensional and were assessed using a suite of questions. To account for this, we condensed answers to 13 questions (A1, A2, A3, A4, A5, A6, A7, A8, A9, A11; A12, A3, A14; Table 2) to a single "attitude" variable using a principal component analysis (PCA), implemented using the packages "FactoMineR" and "factoextra"(Lê et al., 2008; Kassambara and Mundt, 2020). We omitted answers to A10 and A15 because the interpretation of the corresponding answers was not unambiguous. Reliability of the responses, tested using Cronbach's α via the "ltm" package (Rizopoulos, 2006), was acceptable for the responses pertaining to European bison and moose ($\alpha = 0.74$ for both species) and good for responses pertaining to wolf ($\alpha = 0.81$) (Rizopoulos, 2022). In line with Arbieu et al. (2019), we used the loadings of the first dimension of each species-specific PCA as the response variable of generalized linear models (see Table 2 for contributions of each question to the response variable for each species).

To explain the observed variation in attitudes (condensed and represented by the PCA loadings of the first dimension) regarding each target species, we considered a suite of explanatory variables that were related to formal knowledge, exposure and previous experiences with each of the three target species, and the socio-demographic background

Table 2
Contribution of 13 questions to the first dimension of species-specific principal component analyses to summarize attitudes towards returning wildlife species. The first dimension explained 41.2 %, 38.2 %, and 54.55 % of the observed variation for European bison, moose and wolf, respectively.

Questions	European bison (%)	Moose (%)	Wolf (%)
A1. What is your **personal opinion** towards the species?	5.99	5.84	9.44
A2. How would you **feel** about this species living in the wild in Germany?	12.23	11.36	10.59
A3. Would you be **happy** to see this species in the wild in Germany?	11.14	11.27	8.33
A4. Would you **agree** that this species should live freely in Germany?	10.54	11.29	11.02
A5. Would you **agree** that this species should live freely in the state of **Lower Saxony (Springe)/Berlin Brandenburg (Schorfheide)**?	10.85	10.96	11.14
A6. How should the **population size and distribution** of this species develop in **Germany**?	10.18	11.61	9.63
A7. How should the **population size and distribution** of this species develop in **Lower Saxony/Berlin Brandenburg**?	9.62	10.08	9.21
A8. How should "**problem-animals**" (e.g. a wolf that repeatedly attacks husbandry animals; a European bison/moose that repeatedly destroys trees) be dealt with?	1.26	0.70	2.47
A9. This species has the **same right** as other species to live in the wild.	9.84	10.00	8.65
A11. This species **enriches** nature and the landscape.	8.80	8.88	6.57
A12. It is important to preserve this species for **future generations**.	3.98	4.30	4.68
A13. The presence of this species in the wild **scares** me.	3.42	2.54	5.13
A14. The presence of this species in the wild will **limit my leisure activities**.	2.16	1.16	3.14

of the interviewees.

Formal knowledge of each target species was the only numeric variable ranging from 0 to 7 points for each species. Each point corresponds to one correct answer in the animal quiz section (Fig. S1; Section B). As proxies for exposure to each species, we chose (1) the location of the park (two-level variables: Springe and Schorfheide) and (2) the residential status of the interviewee (four-level variable: rural, rather rural, rather urban and urban, based on self-assessment of the participants). As proxy for previous experiences with the target species, we used the responses to the question: whether interviewees had seen the species in the wild (yes or no). For the wolf model, we also included responses to the question if participants or someone they knew had suffered physical or economic damages inflicted by wolves (yes or no). We did not include this variable for the European bison and moose model because the frequencies of yes answers were marginal. Among the sociodemographic variables, we tested if gender (two-level categorical variable: female and male; in total two interviewees identified as non-binary and due to this small sample size, we omitted these cases) and age (six-levels: 18 to 24, 25 to 29, 30 to 39, 40 to 49, 50 to 59 and over 60 years of age) affected attitudes towards the species (Fig. 2). Before fitting species-specific models, we assessed collinearity among the explanatory categories using the Cramer's V index for categorical variables and the Epsilon Square test statistic for the numerical variables. For these tests, we used the packages "vcd" and "rcompanion" (Meyer et al., 2020; Mangiafico, 2021). There were no strong signals for collinearity between the variables (Table S1). For each target species, we fitted a generalized linear model (Gaussian error distribution) with all variables (six explanatory variables for European bison and moose; seven for wolf) using the "MASS" package (Venables and Ripley, 2002). Because we were mainly interested in the effects of different explanatory variables (and less interested in making predictions) we did not conduct formal model

selection (Tredennick et al., 2021).

To visualize the models, we displayed the predictor effects (i.e. estimating predicted values across values for this predictor, holding everything else in the model equal), using the "effect_plot" function of the "jtools" package (Long, 2022) and plotting with the "ggplot2" and "ggpubr" packages (Wickham, 2016; Kassambara, 2020).

3. Results

3.1. Sociodemographic background of the interviewees

Table 1 summarizes the participants' sociodemographic background (state of residence, residential status, gender and age) in each of the two wildlife parks. In Schorfheide, 81.3 % of the participants lived in the state Brandenburg (where Schorfheide is located) or the adjacent city and constituent state, Berlin, while 91.0 % of the participants in Springe were from Lower Saxony (where Springe is located). The majority of participants in Schorfheide were residing in urban (48.6 %) or rather urban (16.2 %) areas, whereas the majority of participants in Springe resided in rural (34.3 %) or rather rural (27.2 %) areas. In both parks, there were more female participants (female participants: 55.6 % in Springe and 53.6 % in Schorfheide). The most frequent age group was between 30 and 49 years of age in both wildlife parks (Springe 42.1 % and Schorfheide: 49.9 %), while the number of participants aged 18 to 24 was markedly higher in Springe (14.6 %) than in Schorfheide (5.0 %).

3.2. Attitudes towards the three wildlife species

The responses to the questions that gauged "Perceptions and attitudes towards the species" are summarized in Fig. S2; more details of the questionnaire design can be found in Fig. S1. The majority of interviewees associated moose (Springe: 64.9 %; Schorfheide: 72.9 %) and European bison (Springe: 50.0 %; Schorfheide: 58.6 %) with very positive sentiments (A1). In contrast, positive sentiments towards wolves were less prevalent (Springe: 46.6 %; Schorfheide: 53.9 %). For the questions associated with the presence of the species in Germany (A2, A3, A4), the participants in Schorfheide tended to have more positive attitudes towards all three species compared to those in Springe (Fig. S2a).

In both wildlife parks, there were no marked effects of perceived distance between the respondents' residence and free ranging populations on attitudes towards the species observed (comparing A4 vs. A5, A6 vs. A7). While the majority of visitors stated that they preferred an increase in European bison (Springe: 63.1 %; Schorfheide: 68.2 %) and moose populations (Springe: 64.9 %; Schorfheide: 72.0 %) in Germany, relatively few interviewees (Springe: 31.3 %; Schorfheide: 31.2 %) preferred an increasing wolf population (Fig. S2a). When confronted with the question of how to deal with "problem animals" (here defined as animals which had repeatedly caused the damage; A8), most visitors (Springe: 39.9–45.9 %; Schorfheide: 50.8–56.1 %) responded that relocating the animals to nature reserves would be the best solution. More than three times as many interviewees chose the option to kill the problem wolf (Springe: 10.4 %; Schorfheide: 7.2 %) than a problem European bison (Springe: 3.0 %; Schorfheide: 1.2 %) or moose (Springe: 2.6 %; Schorfheide: 1.2 %).

The majority (>80 % for European bison and moose; >70 % for wolf) of visitors in both wildlife parks acknowledged the species' right to live freely in nature (A9), its value for the natural environment (A11), and its conservation value (A12). The percentage of visitors who were afraid of encountering a wolf (A13) or who thought that its presence would restrict their leisure activities (A14) was <25 % in both wildlife parks (<15 % for both species in both wildlife parks).

3.3. Exposure to the three wildlife species

Between 8 and 11 % of visitors in both wildlife parks had seen a free-ranging wolf either within (E2) or outside (E3) Germany (Fig. S3). Few visitors had seen a European bison or a moose roaming freely in Germany (Springe: 2.2–3.4 %; Schorfheide: 4.4–5.0 %). While few participants had experienced physical or economic damage inflicted by wolves themselves (E4: 3.0 % in Springe and 1.9 % in Schorfheide), 10.4 % of interviewees in Springe and 6.9 % in Schorfheide reported that someone they knew had experienced these damages (E5). For moose and European bison, these percentages were <2 %.

3.4. Correlates of attitudes towards the three species

To condense responses to one attitude measure for each species, we used a PCA. The set of questions with the highest contributions to the loadings of the first PCA dimension differed between target species (Table 2). For European bison, items which substantially contributed to the first PCA dimension included responses pertaining to participants' perceptions of the species (A2 to A5), preferred population size (A6) and responses concerning the intrinsic value of the species (A9). For moose, the set of questions with the highest contributions to the first PCA dimension were those focussing on the participants' perception of the species (A2 to A5) and the preferred population size of the species (A6 and A7). For wolf, the set of questions with the highest contributions to the first dimension of the PCA was similar to the European bison, including responses pertaining to perception (A1, A2 and A3 to A5), preferred population size (A6 and A7) and intrinsic value of the species (A9).

Regression coefficients of variables explaining variation in attitudes towards European bison are summarized in Fig. 3 and Table S2. Male respondents tended to have slightly more positive attitudes than female respondents, yet the effect size was small and confidence intervals between the two levels overlapped (Fig. 3a). In the first five age classes, attitudes were roughly similar as indicated by overlapping confidence intervals, yet respondents in the oldest age class had markedly more negative attitudes towards European bison (Fig. 3b). Attitudes did not markedly differ between the two wildlife parks (Fig. 3c). Attitudes were correlated with residential status, with respondents from urban areas having more positive attitudes than respondents from rural areas (Fig. 3d). Similarly, formal knowledge was positively correlated with attitudes (Fig. 3e). People who had seen a European bison in the wild also tended to have more positive attitudes than people who had not seen a wild European bison (Fig. 3f), but confidence intervals between predicted effects overlapped. Model fit was poor (X^2 (12) = 229.15, $p <$ 0.01) and the model explained little of the observed variation (Cragg-Uhler Pseudo-R^2 = 0.09).

Similar to the European bison model, age, residential status and knowledge of the species markedly influenced attitudes towards moose (Fig. 4 and Table S2). Gender had little to no effect on attitudes (Fig. 4a). Attitudes among respondents in the first five age groups were similar, whereas participants aged over 60 years had substantially more negative attitudes than respondents in younger age groups (Fig. 4b). Attitudes did not differ markedly between the two wildlife parks (Fig. 4c). The attitudinal gradient from urban to rural areas was also manifested in the moose model (Fig. 4d), but was only distinct when comparing the two extremes of the categorical variable. Respondents with more knowledge about moose had more positive attitudes (Fig. 4e). Respondents who had seen a wild moose had slightly more positive attitudes than respondents who had not seen them in the wild, but the effect size was small and confidence intervals overlapped. As for the European bison model, model fit was poor (X^2 (12) = 200.80, $p < 0.01$) and the model explained a small amount of the observed variation (Cragg-Uhler Pseudo-R^2 = 0.09).

For wolves, age, residential status, knowledge and previous negative experiences markedly affected the participants' attitudes (Fig. 5, Table S2). Gender did not substantially mediate attitudes (Fig. 5a). Participants in most age groups had similar attitudes, whereas a marked drop in attitudes was evident for respondents aged 60 and above

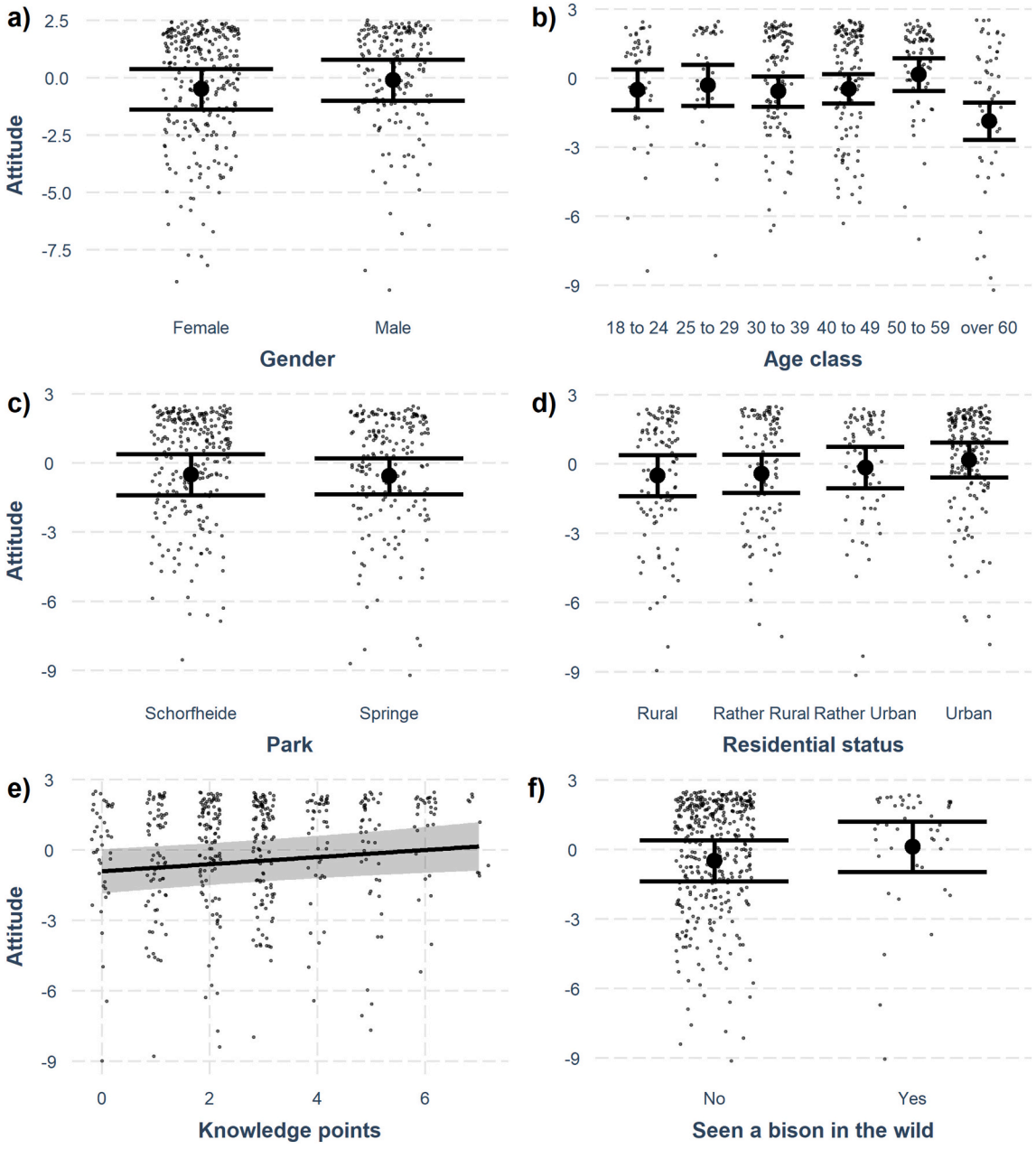

Fig. 3. Predictor effects (i.e. estimated predicted values across values for this predictor, holding everything else in the model equal) based on a general linear model, testing the effect of knowledge, exposure, and sociodemographic variables on the attitudes towards European bison among interviewees in the wildlife parks Springe and Schorfheide.

(Fig. 5b). Attitudes did not differ substantially between wildlife parks (Fig. 5c). Attitudes followed a similar urban-rural gradient, whereby the differences in attitudes along the urban-rural gradient towards wolves were stronger than for the two other species (Fig. 5d). Similar as in the models for the other two species, formal knowledge was positively correlated with attitudes (Fig. 5e). Whether respondents had seen a wild wolf or not did not substantially affect attitudes. However, previous experiences of physical or economic damages inflicted by wolves had a markedly negative effect (Fig. 5g). Similar to the models for European bison and moose, model fit was poor (X^2 (13) = 627.77, $p < 0.01$) and the model explained a relatively small amount of the observed variation (Cragg-Uhler Pseudo-R^2 = 0.19).

4. Discussion

Our comparative, multi-species approach to gauging people's attitudes towards three returning wildlife species highlights that peoples' attitudes differ by species. Moreover, comparing the results of species-specific models suggests that both species-specific and universal factors influence attitudes towards wildlife species. The key universal finding was that participants with higher knowledge showed more positive attitudes towards European bison, moose, and wolf. However, the poor model fit observed in all species-specific models, indicates that factors influencing attitudes towards wildlife species are complex, and are insufficiently explained by the chosen variables in this study.

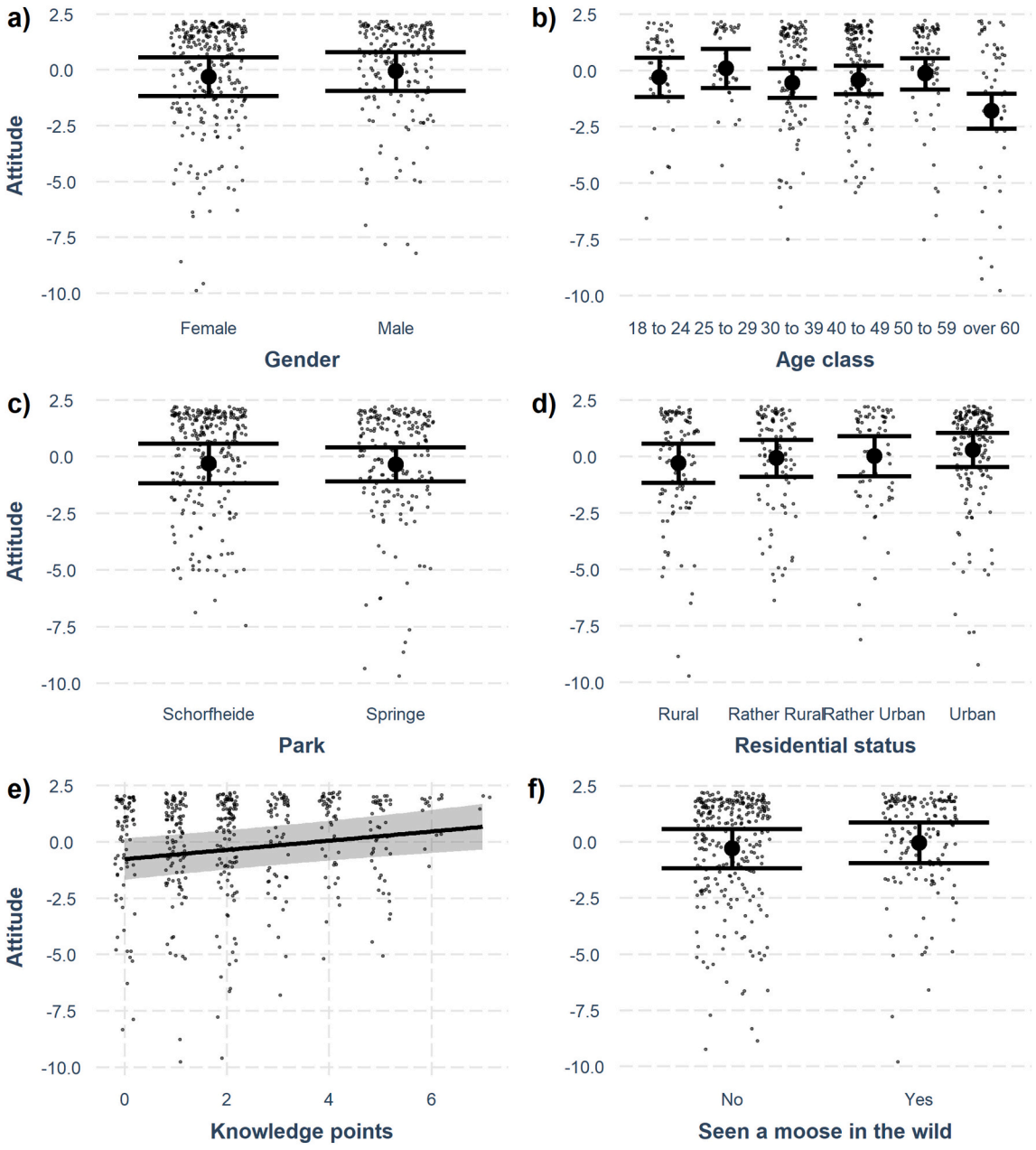

Fig. 4. Predictor effects (i.e. estimated predicted values across values for this predictor, holding everything else in the model equal) based on a general linear model, testing the effect of knowledge, exposure, and sociodemographic variables on the attitudes towards moose among interviewees in the wildlife parks Springe and Schorfheide.

4.1. Attitudes towards the three returning mammals

For questions related to perceptions and attitudes, participants showed considerably more positive attitudes towards European bison and moose compared to wolf. While large, charismatic mammals typically attain greater public conservation support compared to less iconic taxa (Colléony et al., 2017), it could be that human attitudes are partially driven by the feeding type of the focal species (i.e. carnivores vs. herbivores). Globally, humans have caused declines and extinctions in both herbivores and carnivores, yet the motive for such human-caused declines may broadly differ: declines in herbivores are often linked to overharvest for meat or body parts (Ripple et al., 2015), whereas carnivore declines are often associated with retaliation in response to livestock predation or attacks on humans (Ripple et al., 2014; Ronnenberg et al., 2017). Consequently, carnivores tend to be linked with more negative emotions such as fear and anger (Kleiven et al., 2004; Lute and Carter, 2020; Arbieu et al., 2021). The widespread and often stereotypic negative picture of the wolf (Jürgens and Hackett, 2017), which is historically reinforced in stories and fairy tales (Linnell et al., 2002), could be further amplified by media reports on livestock predation and attacks on pet animals. This can provoke emotionally charged reactions (Rode et al., 2021), which are often politicised (Darimont et al., 2018) and may contribute to a widespread, and possibly exaggerated belief of wolves as dangerous animals (Fig. S2b; A13).

Another difference between the two herbivores and the wolf in this context is their recolonization history: wolves are already relatively widely distributed in Germany (Reinhardt et al., 2019), while moose sightings (Gandl, 2020) and the reintroduction of the European bison in the “Rothaargebirge” have occurred only within the last 10 years

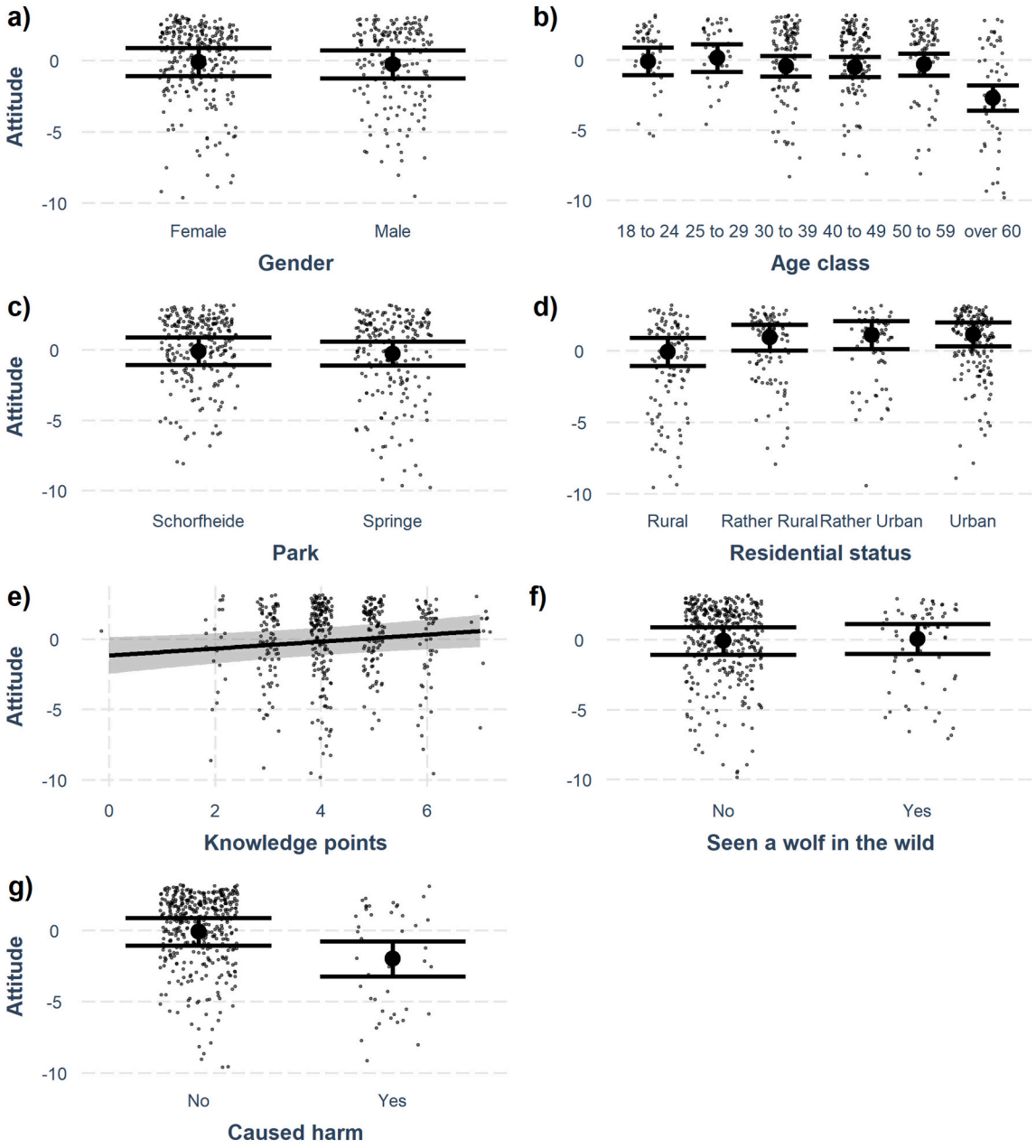

Fig. 5. Predictor effects (i.e. estimated predicted values across values for this predictor, holding everything else in the model equal) based on a general linear model, testing the effect of knowledge, exposure, and sociodemographic variables on the attitudes towards wolf among interviewees in the wildlife parks Springe and Schorfheide.

(Jensen et al., 2020). The distribution of both herbivores is thus localized, and where they occur, they exist in low numbers (Corlatti and Zachos, 2022). Studies accompanying attitudinal changes of stakeholders towards wolves found that longer exposure and associated increases in negative experiences (mainly livestock predation) reduced tolerance and increased support for lethal control among affected stakeholders (Treves et al., 2013; Browne-Nuñez et al., 2015). While results of our study partially supported this notion (e.g. A8: more than double of interviewees choosing to kill a problem wolf compared to a problem European bison or moose; Fig. S2), it is difficult to disentangle whether the recolonization history or the species' traits influenced individual attitudes. Although lethal control is often hypothesized to gain public support, killing animals does not always increase tolerance among stakeholders (Browne-Nuñez et al., 2015) and is often ineffective in reducing livestock predation in the long term (Wielgus and Peebles, 2014).

In our study, exposure and experience affected people's attitudes both positively and negatively. Visitors who had previously observed wild European bison expressed more positive attitudes towards the species. However, visitors who directly or indirectly had experienced damage by wolves had more negative attitudes towards wolves. These positive and negative attitudes were directly related to people's living environment, thereby aligning well with the rural-urban gradient: visitors residing in urban areas, where interactions with large mammals are unlikely to occur or affect one's livelihood, had generally more positive attitudes towards all three species (Figs. 3d, 4d, 5d). This rural-urban polarization has been repeatedly shown in HWC studies (Dickman, 2010; Balčiauskas and Kazlauskas, 2013; Tan et al., 2020; Klich et al., 2021; Ostermann-Miyashita et al., 2021; Vaske et al., 2021), as negative interaction of human and wildlife tends to occur more often in rural areas (Bogezi et al., 2019). We notice, however, that the effect of this rural-urban gradient was rather small and that variation in each

category was relatively large (see observed data in Figs. 3d, 4d, 5d). Therefore, we caution against overgeneralization and stereotyping of this finding.

Among the sociodemographic variables tested, age was the only variable that mediated attitudes towards all three species. While many studies highlighting the increasing environmental awareness in today's youth (Lischka et al., 2019; Salman et al., 2020; Shafiei and Maleksaeidi, 2020; Haugestad et al., 2021) including a more positive attitude towards wildlife (George et al., 2016; Zheng et al., 2022), this tendency was not clearly visible in this study. For all species, the main effect was that attitudes dropped markedly among respondents in the oldest age group (60 years and above). One possible explanation for this is a phenomenon known as the "shifting baseline syndrome", where the state of 'normal' changes for each generation, creating a different 'baseline' for assessing a situation (Martínez-Abraín et al., 2019). In this specific case, the participants aged 60 and above possibly grew up in a time, when the value of wildlife in society differed from more recent wildlife value orientations (Kaltenborn and Linnell, 2022). However, this still leaves unanswered questions (e.g. why such changes are manifested via an apparent drop and not a more gradual difference), and we suggest follow-up studies to identify the underlying reasons.

Although the effect of gender observed for European bison (males having more positive attitudes) was in line with a previous study (Klich et al., 2018), the effect size was small. Similarly, gender did not markedly affect attitudes towards other species. In sum, this study underlined that broad demographic variables poorly predict attitudes towards wildlife (Kansky and Knight, 2014), a finding that severely complicates predicting attitudes towards wildlife.

4.2. Knowledge as key to improving attitudes

A key finding of this study is that knowledge of a species was positively correlated with attitudes for all three target species. Pinning down which factors influence an individual's formal knowledge of a specific species (Ostermann-Miyashita et al., 2022) is difficult as it relies on a complex set of intrinsic and extrinsic values, cultural and sociodemographic context (Manfredo and Dayer, 2004; Lute et al., 2014) as well as individual experience (Kansky et al., 2016). Nevertheless, the consistent effect of formal knowledge on attitudes towards wildlife species suggests that environmental education can possibly be a promising strategy for mediating attitudes towards wildlife species and improving the effectiveness of conservation efforts. Multiple studies have pointed out the importance and positive impact of awareness campaigns addressing the public (Jefferson et al., 2015; Tan et al., 2020) for gaining public support for conservation activities, especially when targeting non-charismatic species (Martín-López et al., 2007). Providing information about an endangered species has been shown to increase willingness for supporting its conservation, whereas people who did not obtain prior information about the species tended to primarily support more iconic, but less threatened species (Curtin and Papworth, 2018). This suggests that public support can be guided by campaigns and targeted information supply. While scientific mainstream literature, as well as local media (TV, newspaper, radio) continue to be effective tools for informing the public, social media is also gaining momentum in wildlife conservation in today's fast moving digital world (Wu et al., 2018; Cash and Belloy, 2020).

Although knowledge is a variable that can be directly influenced through adequate measures, this does not necessarily mean that increasing formal knowledge will always improve attitudes towards wildlife species. Direct, negative impacts of wildlife can swiftly change initially positive attitudes to aversion against a species (Treves et al., 2013). Moreover, value and belief systems that underlie attitudes towards wildlife are often deeply engrained in cultures; this does not prevent attitudinal change per se, but likely explains why attitudinal changes are slow (Manfredo et al., 2020; Macdonald et al., 2022).

5. Conclusion

The results of this study underpin the importance of knowledge for conservation and resonate with the famous quote by Baba Dioum (1968), "*In the end we will conserve only what we love; we will love only what we understand; and we will understand only what we are taught*." An individual's knowledge about a specific species is affected by many intrinsic and extrinsic factors such as the social environment, highlighting the importance of providing opportunities and information on accessible platforms, integrating conservation topics into formal school education, and improving public awareness of wildlife conservation (e.g. campaigns and programs by NGOs) and Citizen Science (voluntary involvement of citizens in scientific research) in wildlife management and conservation projects. Gaining public support is essential for realizing a better coexistence of humans and other species, and providing people with sufficient information is a meaningful first step.

CRediT authorship contribution statement

Emu-Felicitas Ostermann-Miyashita: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Visualization, Project administration. **Nadja Pernat:** Resources, Writing – review & editing, Supervision. **Hannes J. König:** Conceptualization, Resources, Writing – review & editing, Supervision, Project administration, Funding acquisition. **Karoline Hemminger:** Writing – review & editing. **Nina Gandl:** Writing – review & editing. **Sonoko Dorothea Bellingrath-Kimura:** Writing – review & editing, Supervision. **Sophia Hibler:** Writing – review & editing. **Christian Kiffner:** Methodology, Formal analysis, Resources, Writing – review & editing, Visualization, Supervision, Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.biocon.2022.109878.

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