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RESEARCH ARTICLE

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Danger versus fear: A key to understanding biophobia

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Abstract

1. Which animals do people fear most, and why? Exploring animal fears in humans is crucial for understanding reactions in the face of danger, addressing both innate and learned determinants. Because of the central role they are thought to have played in primate evolution, most studies have focused on the fear of snakes. Other studies that have looked at a wider range of animals have either focused on a limited number of species and/or sampled participants from a narrow range of geographical locations.
2. To overcome these shortcomings, we developed an immersive online survey based on animal images matches, during which participants had to choose the animal they feared most. With responses from 17,353 participants from all continents, we were able to rank 184 species (mammals, reptiles, birds, arthropods and amphibians) on a fear scale.
3. Our results showed that images of dangerous animals elicited frequent and rapid fear responses. However, danger alone was not sufficient to explain fear, as harmless animals also reached high fear scores. Fear responses varied with participants' age, geographical region of residence and level of declared biophobia.
4. The discrepancy between actual levels of danger and declared fears in humans may be due to social transmission and increasing disconnection from natural environments. This study highlights the need to consider a wide range of animal species to identify and understand people's fear of certain species, integrating the complex relationship between ecological danger and socio-cultural influences.

KEYWORDS
biophobia, fear of animals, internet survey, predators, social transmission

1 | INTRODUCTION

Human perception of wild animals can trigger a variety of emotions, from indifference to fascination, through disgust, affection, but also apprehension and intense fear. Darwin (1872) portrayed fear as an emotion that 'often acts at first as a powerful stimulant' to evade major threats, thus conferring crucial fitness advantages under natural conditions. Indeed, fear is an adaptive emotional state commonly experienced by humans and forms part of complex defence and danger avoidance mechanisms that have evolved over millions of years (Adolphs, 2013; Hofmann et al., 2002). Predators and dangerous animals (e.g. snakes) were major ecological threats throughout primate diversification. According to primate evolution theories, this led to the development of specific traits, such as a visual specialisation and expanded brain for rapid detection of threats (Isbell, 2006). Various studies have found a direct association between danger and fear in humans, with dangerous animals, such as sharks, crocodilians, venomous snakes or large carnivorans being ranked among the scariest due to their size, venom or visible weapons (Frynta, Elmi, Rexová, et al., 2023; Staňková et al., 2021).

However, as humans become increasingly disconnected from the natural environment, adaptive fear responses to ecological danger are gradually shifting to irrational and maladaptive fears known as phobias (Imai et al., 2019; Soga & Gaston, 2016). Animal phobias are diagnosable anxiety disorders characterised by a persistent, exacerbated and irrational fear of an animal (a single species or broader taxonomic groups), which is disproportionate to the actual danger posed by the animal, and consequently either strenuously avoided or endured with significant distress (American Psychiatric Association, 2013). The growing extinction of experience with nature, particularly notable among children, is directly connected to the increase in animal phobias and more generally in biophobia, which involves strong negative emotions (e.g. fear, disgust and dislike) associated with aversive responses and attitudes towards nature (e.g. intentional killing of wildlife; Gaston & Soga, 2020; Soga et al., 2020, 2023). This vicious cycle of biophobia, influenced by environmental and socio-cultural factors, can explain the development and persistence of specific biophobias, even if the specific animals are not inherently dangerous to humans (e.g. phobia of mice or bats; Soga & Evans, 2024). Indeed, recent research has highlighted a correlation between the development of snake and spider phobias and socio-cultural environment: participants who express a stronger subjective connection with nature tended to score lower on snake and spider phobia questionnaires (Zsido et al., 2022). Sociodemographic factors have also been found to influence the prevalence and intensity of fear, with women reporting higher snake phobia and fear scores for snakes than men (Fredrikson et al., 1996), and younger individuals showing a greater tendency to fear snakes and other dangerous animals (Pereira et al., 2023). Education has been shown to positively influence the perception of wild animals in both adults and children through supervised encounters with wild species (Ballouard et al., 2012). However, little to no evidence was found regarding variations in fear levels across different geographical regions. For instance, fear evaluations of various snake species showed high agreement across geographically distant participants, with vipers being consistently ranked as the highest frightening species (e.g. Czech and Somali participants: Frynta, Elmi, Janovcová, et al., 2023; Czech and Azerbaijani participants in Landová et al., 2018). Similarly, Prokop et al. (2010) found comparable spider fear levels among Slovakian and South African high school students. Conversely, while there was a broad consistency in how feared animals are categorised across seven countries, a cross-cultural study revealed that Indian participants reported lower fear levels towards spiders compared with participants from other countries like the United States of America (Davey et al., 1998).

Overall, previous studies aiming at understanding the relative contribution of ecological (e.g. direct experience with danger) and socio-cultural (e.g. transmission of threat information) drivers in the development of fears and phobias towards animals often lack diversity in the range of species considered or in the range of participants' socio-cultural backgrounds (i.e. number of different countries considered). Thereby, expanding research to include large, geographically diverse participant cohorts and a wider variety of animals is essential for understanding the complex interplay between danger and fear, and addressing both innate and learned determinants of biophobia in humans. Here we report the results of an international online survey investigating the perception of a large taxonomic diversity of species with a gradient of potential danger levels to humans. This study enabled us:

- to rank a substantial number of animals based on the level of fear they inspire and
- to assess the influence of ecological and socio-cultural factors on the level of fear evoked by both dangerous and harmless animals.

According to evolutionary theories, we expected dangerous taxa like snakes, large carnivorans and crocodilians to consistently rank among the top fear-evoking animals. However, hypotheses regarding the social transmission of fears—with socio-cultural events influencing the development and persistence of specific emotional reactions—led us to predict that the scariest animal taxa might vary across different geographic regions and age groups due to factors, such as education and direct exposure. Additionally, the level of fear towards dangerous and harmless animals might also fluctuate across populations from different geographic regions depending on the specific species present locally.

2 | MATERIALS AND METHODS

2.1 | Procedure

The 'Lost in Wilderness' online survey was distributed from April 2020 to September 2021 through various channels, including social media and mailing lists within personal and professional networks. It was anonymised and accessible in French, English, Spanish and

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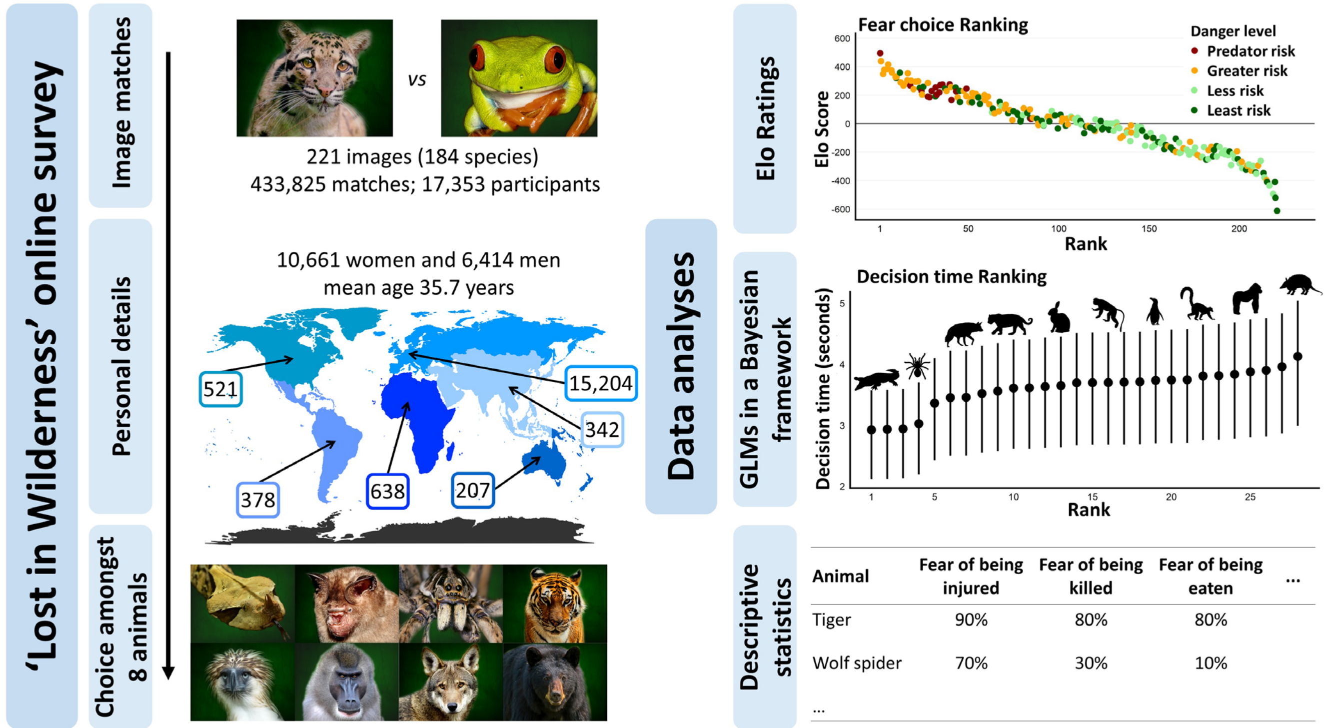

FIGURE 1 Workflow of the 'Lost in Wilderness' online survey and the different analyses and methods employed. In the first part, pairs of animal images (in the figure: *Neofelis nebulosa* versus *Agalychnis callidryas*) were presented and participants had to click on the animal they feared the most. In the second part, participants answered questions regarding personal information. Decision outcomes and decision times during image matches were analysed using Elo ratings and Bayesian GLMs. In the third part, participants faced eight animal images (*Bitis gabonica*, *Hipposideros speoris*, *Lycosidae* sp., *Panthera tigris*, *Pithecophaga jefferyi*, *Mandrillus leucophaeus*, *Canis rufus* and *Ursus americanus*) and had to choose the one that scared them the most before answering questions characterising the fear of the selected animal. Proportions of participants selecting each of the eight possible animals, as well as the proportions of participants declaring being afraid of being injured, killed or eaten by the animal they selected were calculated.

German. Participants began the survey with a textual introduction designed to immerse them in a narrative where they imagined being lost alone in the wilderness. They had to progress by clicking on the animal that scared them the most whenever animals would appear on the screen, and had to reach a rescue station where they would need to provide personal information to be rescued. We structured the survey into three parts (Figure 1). The first part was hosted on the online platform Biodiful (www.biodiful.org) while the second and third parts were hosted on a Google Form linked to a unique anonymous code generated by the Biodiful website for each participant. The survey and data collection complied with the French Data Protection Act (Loi Informatique et Libertés n°78–17 du 6 janvier 1978), the General Data Protection Regulation (GDPR, Règlement UE 2016/679 du Parlement européen et du Conseil du 27 avril 2016) as well as the Helsinki Declaration. Informed consent was obtained from all participants by clearly explaining the purpose of the study on the first page of the survey and asking them to actively click a button to confirm their acceptance and begin the survey. No personal or identifiable details were requested or collected from any participants. Participants could stop at any given moment and data were not recorded in this situation. Participants were given an anonymous code they could use if they wanted to withdraw from the survey after completion.

2.2 | Variables

2.2.1 | Participant demographics

In the second part of the questionnaire, we recorded the gender, age, dominant hand, geographic region of residence, geographic origin of the parents, academic level, naturalist knowledge, main centre of interests and movie genre preference for each participant (Online Resource 1, Table S1).

2.2.2 | Pool of animal species and images used

We focused on non-aquatic animals (e.g. terrestrial, arboreal, aerial, etc.) as we used a narrative where the participants were supposed to walk on land and encounter wild animals. Animals were chosen to compile a gradient of dangerousness, to be recognisable by non-specialists and to cover a broad taxonomic level resulting in a higher representation of mammals, reptiles and birds compared with amphibians, arachnids and insects. For the first part of the survey, we used a collection of 221 colour photo portraits of animals, corresponding to 184 different species (several species were represented more than once in the collection to add little intraspecific variation).

During this part, each participant had to choose the image they found the most frightening for 25 pairs (hereafter called 'matches') randomly sampled among the 221 images. The decision time (in seconds) was also recorded for each match. The number of image matches was set at 25 to provide sufficient repetition per participant for reliable data collection while minimising participants fatigue and reducing the likelihood of dropout due to an excessive survey duration. In the third part, the participant had to choose the animal that scared them the most from eight animals. We used images of taxonomically diverse species with different levels of dangerousness to humans, including two predators (the tiger and the American black bear) two dangerous animals (the Philippine eagle and the drill), two harmless animals (the red wolf and a bat), as well as two representatives of the taxa most commonly associated with animal phobias: a spider and a snake (Figure 1). This part with a choice between the eight images was also intended to give the participant a choice between the fear of an animal that looks repulsive and disturbing but not very or not at all dangerous, and the real ecological threat of a repulsive and dangerous animal. In addition, this part aimed to explore the reasons behind participants' fear by asking explicitly what frightened them about the selected animal. Therefore, participants rated (from 0 to 4) the level of fear they felt for the animal they chose, and responded to three questions characterising their fear: fear of being injured, fear of being killed and fear of being eaten. They then had to answer a question regarding their potential previous encounter with the selected animal. Finally, they were asked to indicate whether they considered themselves as phobic of snakes, spiders or other animals, or non-phobic. Most of the images were photo portraits taken by Xavier Bonnet and Antoine Joris, the others were mainly gathered via copyright-free photo websites, naturalist photographers and colleagues. All images were clipped, placed on a textured dark green background (see Figure 1 for examples) and resized (to be at 1600×1200 pixels) with the Gimp software v2.8.22.

2.2.3 | Species classifications

We categorised the 184 species of the first part of the survey according to broad taxonomic classifications. Groups only required a minimum of two species. We started with six classes: mammals ($N=99$ species), reptiles ($N=27$), birds ($N=39$), amphibians ($N=5$), arachnids ($N=5$) and insects ($N=9$). As the imbalance in species numbers could cause high variance in results, complicating interpretations, we divided groups with many species (mammals, reptiles and birds) using finer taxonomic resolution, such as Orders, while keeping species number per group below an arbitrarily set limit of 15, resulting in the formation of 28 groups (Table 1; Online Resource 1, Text A; Additional references). We also classified the 184 species using the Hazardous Animal Categorization from the Secretary of State's Standard of Modern Zoo Practice (www.defra.gov.uk) into three risk levels: greater risk (serious injury or life threat), less risk (injury but not life-threatening) and least risk

TABLE 1 List of the 28 groups encompassing the 184 different species selected.

Group	Number of species	Silhouette
Felids	15	
Hyenas	2	
Mongooses	4	
Canids	6	
Bears and Seals	6	
Musteloids	6	
Lorisiformes, Lemuriformes and Tarsiiformes	9	
Pan-American monkeys	5	
Afro-Eurasian monkeys	7	
Apes	5	
Hoofed mammals	12	
Glires and Tenrecs	7	
Xenarthrans	3	
Marsupials	6	
Bats	6	
Tortoises	2	
Crocodilians	2	
Lizards	7	
Colubroids	11	
Pythons and boas	5	
Higher Landbirds	15	
Australaves	6	

TABLE 1 (Continued)

Group	Number of species	Silhouette
Aquatic and Semiaquatic birds	10	
Basal Landbirds	5	
Fowls	3	
Amphibians	5	
Arachnids	5	
Insects	9	

(not listed in the other categories). Domesticated animals (i.e. the dog, the horse, the cat and the rabbit) were not included in this list, which forced us to propose a classification for those species (Online Resource 1, Text A; Additional references). To align with our hypothesis that fear is more intense towards predators, we added a predator risk category, including species known for predatory behaviours towards humans. This resulted in $N=60$: least risk animals, $N=53$: less risk animals, $N=61$: greater risk animals and $N=10$ predator risk animals (Online Resource 1, Text A; Additional references). The dangerousness level of the eight species used in the third part of the survey was determined using the same classification.

2.3 | Data analyses

Prior to the analyses, we excluded incomplete surveys ($n=2410$), withdrawals ($n=2$) and participants under the age of three ($n=3$; because we felt it was not possible to carry out the survey independently at very young ages), for a total of $N=17{,}353$ participants. We first ranked animals based on the fear they inspired by using the answers collected in the first section of our survey and the Elo ratings (Elo, 2008); we used EloChoice v0.29.4 R package (Neumann, 2019) with 1000 randomisations of the order of the matches.

We ranked the 28 animal groups based on the probability to be selected during a match by fitting a generalised linear model (GLM) with a Bernoulli link function. The binary response variable represented the participants' choice between the two images (Image 1 on the left and Image 2 on the right). Predictors included the animal category of Image 1, the animal category of Image 2 and the interaction between the danger level of Image 1 and the danger level of Image 2. We also considered the interaction between the animal category of Image 2 (being the arbitrarily chosen focal image) and participants' age, gender, geographic region and self-reported animal phobia. These interactions allowed us to predict the probability for an image to be selected according to its category (i.e. taxonomic group) and participants' socio-cultural backgrounds (e.g. geographic region of residence and self-reported snake phobia). For analytic purposes, we categorised age in seven categories (Bogin, 2015): young children (≤5 years old), children (6 to 12 years old), adolescents (13 to 17 years old), young adults (18 to 24 years old), adults (25 to 44 years old), middle-aged adults (45 to 64 years old) and older adults (≥65 years old). We also simplified the geographic location of participants using broader geographic regions (Europe, Africa, North America, Latin America and the Caribbean, Asia and Oceania) following the classification provided by the United Nations publication 'Standard Country or Area Codes for Statistical Use'. Participants who did not specify their gender or geographic region ($n=333$) were excluded before fitting the binomial GLM.

We ranked animal groups based on the decision time during a match by fitting a GLM with a negative binomial link function, suitable for integer values (a decision time equal to zero represented the interval between 0 and 1 s) with possible overdispersion (Winter & Bürkner, 2021). We excluded excessively long decision times using the 99th percentile quantile (17 s) because they could be due to disinterest or technical issues rather than long hesitation delay. Predictors included the animal category of the selected image, the animal category of the unselected image, the interaction between their danger levels, the participant's age category and the rank of the image match in the participant evaluation series (ranging from 1 to 25) to mitigate potential starting effects on decision times (notably in the initial matches).

The third part of the survey allowed us to investigate the potential reasons why participants fear particular animals. We calculated the proportion of participants selecting each of the eight possible animals, as well as the average level of fear and the proportion of participants declaring being afraid to be injured, killed or eaten by the animal they selected. We also calculated the proportion of participants that declared having already encountered the animal they selected (in the wild or in captivity). To maximise participants' chances of understanding the game and therefore the relevance of the answers, we excluded participants under the age of six considering that the concept of death might be unfamiliar or difficult for younger individuals to grasp ($N=114$, Kane, 1979).

We fitted all GLMs in a Bayesian framework using the brm function from the brms v2.21.0 R package (Bürkner, 2017). We used flat (uninformative) priors and ran all models for 5000 iterations across three chains with a warm-up period of 1000 iterations and a thinning rate of 1. We assessed GLMs' convergence by examining trace plots to assess sampling mixing and by ensuring Rhat ≈ 1 (Gelman & Rubin, 1992). To assess the influence of the predictors on the response variable for each GLM, we plotted the distributions of the predicted values (i.e. draws from the expectation of the posterior predictive distribution of the statistical model; Kay, 2023) for each modality within each predictor. Further details of the statistical models and the number of participants for each analysis are available in the Supplementary Material (Online Resource 1, Table S2). We performed all analyses using R v4.4.0 (R Core Team, 2022) in Rstudio v2024.04.2 (RStudio Team, 2022). Credits for the animal

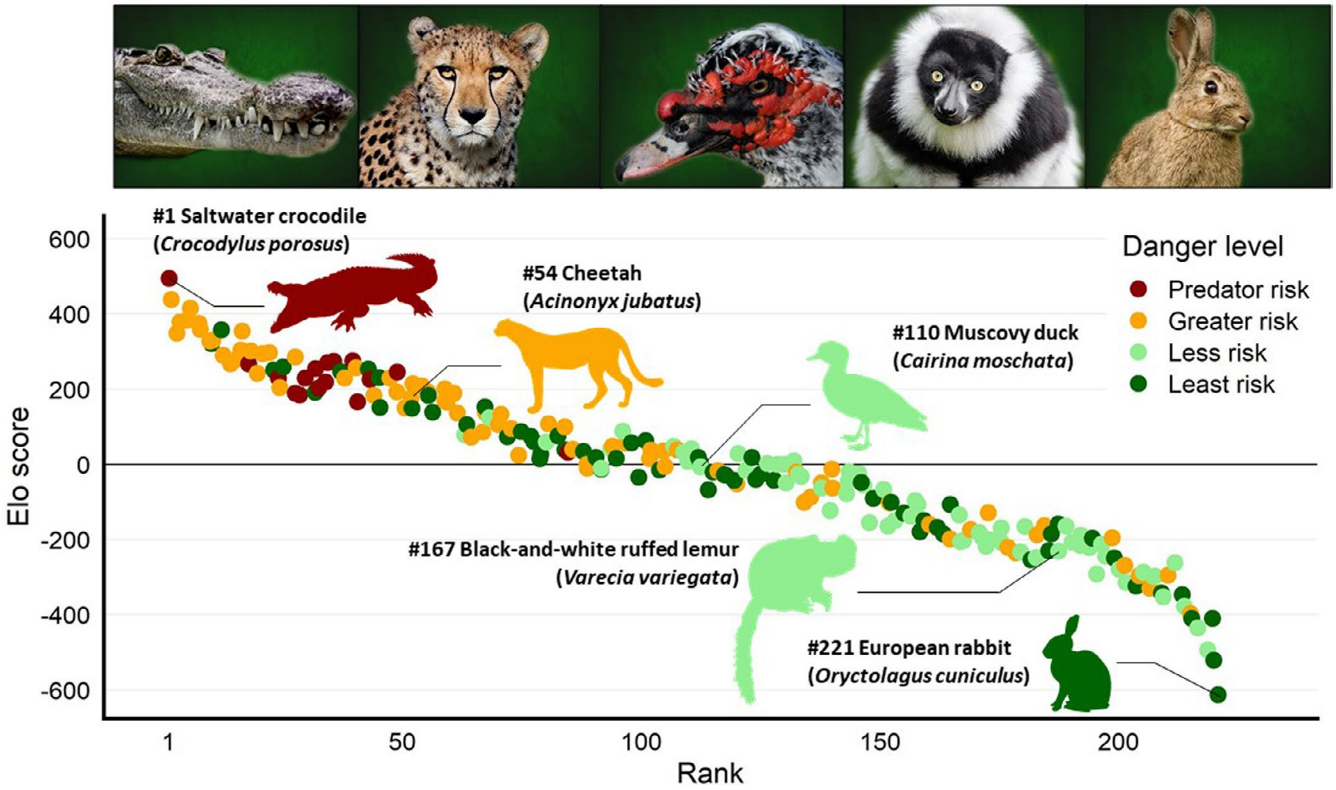

FIGURE 2 Mean fear Elo scores and associated ranks of the 221 animal photo portraits used in the first part of the survey (i.e. the image matches) using the EloChoice with the 433,825 image matches (N = 17,353 participants). The danger level classes are highlighted by point colours. Five examples are given along the ranking for illustration.

silhouettes, used in the figures and downloaded from the website Phylopic v2.0, are available on the Online Resource 1, Table S3. Main results for each question are presented graphically, with detailed statistical results available in the Supplementary Material (Online Resource 1, Tables S4–S15).

3 | RESULTS

3.1 | Participant socio-cultural diversity

Among the N = 17,353 participants, there were n = 10,661 women, n = 6414 men and n = 278 individuals who did not mention their gender. Average age of participants was 35.7 years (SD = 16.36; range: 3–100). The majority answered the survey in French (n = 15,034) followed by English (n = 1911), Spanish (n = 332) and German (n = 76). Participants declared living in Europe (n = 15,204), Africa (n = 638), North America (n = 521), Latin America and the Caribbean (n = 378), Asia (n = 342), Oceania (n = 207) and 63 participants did not provide an answer. Some participants declared being phobic towards spiders (16%), snakes (11%), another animal (10%), or both snakes and spiders (7%), while the majority (56%) declared no biophobia. Details regarding participant distribution across age categories, as well as all other factors corresponding to the 12 personal questions from the second part of the questionnaire, are summarised in Online Resource 1, Table S1.

3.2 | Which animals are the most frightening?

The EloChoice algorithm ranked animal images based on decision outcomes (hereafter 'decision') during images matches out of 221 images: the saltwater crocodile emerged as the most frightening animal while the European rabbit the least (Figure 2). Along with the saltwater crocodile, categorised as posing a predator risk level of danger, a notable proportion of dangerous animals (at predator risk and greater risk levels) also occupied high ranks, such as the Indian cobra (*Naja naja*), the jaguar (*Panthera onca*) or the hippopotamus (*Hippopotamus amphibius*). Such ranking indicates that the participants responded fairly seriously and, as such, other results can be considered reliable.

The taxonomic group with the highest probability to be selected during a match was arachnids (87%), before snakes (colubroids: 76%; pythons and boas: 74%), bats (72%), lizards (70%), insects (70%), crocodilians (70%) and fowls (62%), (Online Resource 1, Tables S4 and S5). Predator images elicited the highest probability to be selected during a match when facing a harmless (less risk: 82%; least risk: 80%) or a dangerous animal (greater risk: 71%).

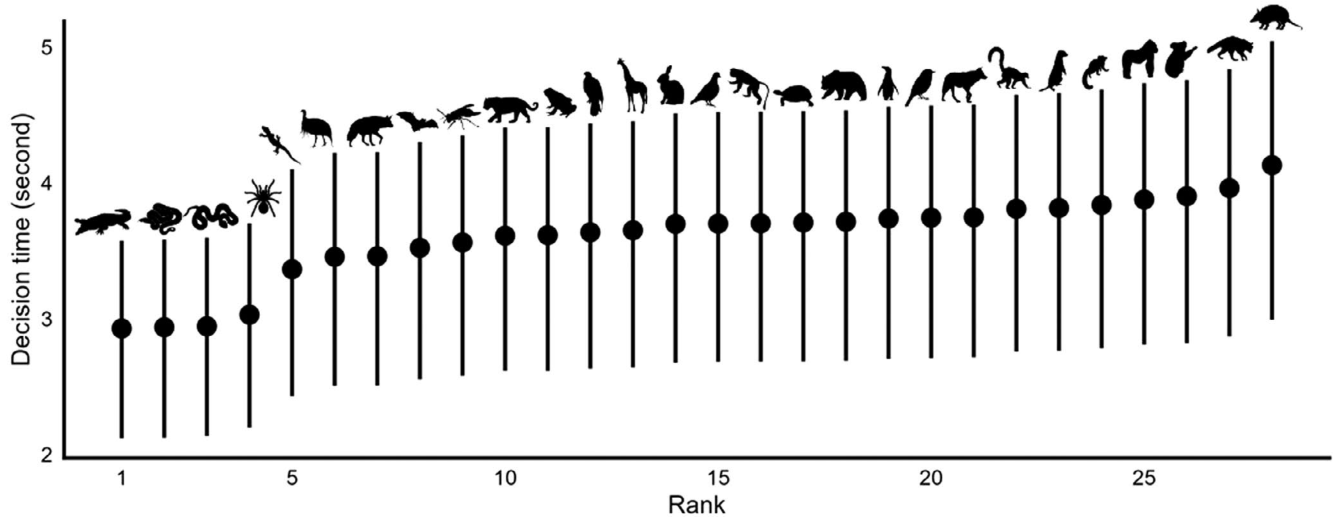

FIGURE 3 Median predicted decision time for an image to be selected during image match along with 75% credible intervals (highest density interval) for each animal category (see Section 2). Animal categories are sorted by median, from lowest to highest.

However, when two predators were confronted, the probability for either one to be selected dropped to chance level (52%, Online Resource 1, Table S6).

The taxonomic group crocodilians elicited the fastest decision time when selected during matches (2.93 s), followed by snakes (pythons and boas: 2.94 s; colubroids: 2.95 s) and arachnids (3.02 s; Figure 3, Online Resource 1, Tables S7 and S8). The danger levels of the two matching images influenced participants' decision time. For instance, the longest decision times were reported when the two images were predators (4.32 s), while the quickest decisions occurred when a predator was selected over a harmless animal (less risk: 3.10s; least risk: 3.12 s; Online Resource 1, Table S9).

3.3 | Who is afraid of which animals?

Across the seven geographic regions of declared residence, arachnids were the most likely to be selected during matches ranging from 85% in Oceania to 89% in Europe. Overall, geographic regions only slightly influenced the choice for the other animal categories. Among the groups which showed some variations, the crocodilians had the highest probability of being selected in Europe (75%), Asia (73%) and Africa (71%), and showed lower probability in North America (69%), Latin America and the Caribbean (65%) and Oceania (65%). Pythons and boas were more likely to be selected in Asia (81%), Latin America and the Caribbean (80%) than in Europe (76%), Oceania (72%), Africa (71%) or North America (66%; Online Resource 1, Table S10).

Selection probabilities were similar between men and women across all animal categories (Online Resource 1, Table S11). Probabilities of selecting crocodilians increased with age, ranging from 50% for children (between 6 and 12 years old) to 81% for older adults (65 years old and over). We found the same pattern for pythons and boas as well as for colubroids, hyenas, felids and bears and seals (Online Resource 1, Table S12). Spiders had the highest probability of being selected across age classes (except in participants over 65); however, participants under 18 years old were more likely to select them than older participants (Online Resource 1, Table S12). Snakes were more likely to be selected by self-reported ophiophobic participants (pythons and boas: 88%, colubroids: 87%) than self-reported non-phobic participants (colubroids: 72%, pythons and boas: 68%) or participants that declared being phobic towards other animals (pythons and boas: 68%, colubroids: 67%). In the same way, spiders were more likely to be selected by self-reported arachnophobic participants (95%) compared with self-reported non-phobic participants (82%; Online Resource 1, Table S13).

3.4 | How did the participants choose the scariest animal?

In the third part of the survey (the eight-image choice), participants selected in majority the harmless (least risk level) wolf spider (27%) and the dangerous (greater risk level) Gaboon viper (27%), followed by the tiger (20%, predator risk level), the black bear (13%, predator risk level), the Schneider's leaf-nosed bat (6%, least risk level), the drill (6%, greater risk level), the red wolf (0.5%, less risk level) and finally the Philippine eagle (0.5%, greater risk level). Self-reported snake phobic participants tended to select the Gaboon viper more than the other animals (68%), while self-reported spider phobic participants tended to select the wolf spider more than the other animals (73%). Participants selecting the tiger indicated a higher level of fear (3.34) compared with participants selecting another animal (Table 2). Participants selecting dangerous animals were afraid to be injured (black bear: 93%, tiger: 92%, Gaboon viper: 65%) and killed (tiger: 76%, black bear: 70%, Gaboon viper: 49%). Participants selecting predators were afraid to be eaten (tiger: 79%, black bear: 54%). Even though the majority of participants selecting the spider were not afraid to be eaten by it, 14% were afraid that it could happen, 30%

TABLE 2 Proportion of participants selecting each of the eight images during the third part of the survey, along with the average reported level of fear and the proportions of participants who were afraid of being injured, killed or eaten by the animal they selected, as well as the proportion of participants who had previously encountered the animal they selected.

Animal	Number of participants	Fear level	Injured	Killed	Eaten	Previous encounter
Philippine eagle	74 (0.4%)	2.28	63.5%	9.5%	16.2%	54.1%
Red wolf	77 (0.5%)	2.68	80.5%	49.4%	61.0%	63.6%
Drill	1026 (6%)	2.59	88.1%	32.6%	15.1%	64.3%
Schneider's leaf-nosed bat	1028 (6%)	2.60	66.7%	21.7%	25.4%	28.1%
Black bear	2293 (13.3%)	3.20	93.0%	70.0%	54.0%	67.9%
Tiger	3533 (20.4%)	3.34	91.6%	76.3%	78.7%	75.9%
Gaboon viper	4599 (26.7%)	3.03	84.5%	48.7%	15.6%	63.1%
Wolf spider	4609 (26.7%)	3.09	65.9%	29.4%	13.8%	59.4%

were afraid to be killed and 66% were afraid to be injured. More than half of the participants declared to have encountered (in the wild or in captivity) the animal they selected, with the exception of the participants selecting the Schneider's leaf-nosed bat (28%, Table 2).

4 | DISCUSSION

Our large-scale survey provided insights on fear towards various animal species among over seventeen thousand participants across the globe, contributing to our understanding of the origins and variations of animal fear and of the relationship between people and nature through the theoretical lens of biophobia. Elo rating calculations indicated that the scariest animal among the 184 species included was the saltwater crocodile and the least feared the European rabbit. Bayesian modelling highlighted that dangerous animals, such as predators, generally elicited faster and more frequent fear responses compared with harmless animals, although fear was not solely dependent on the risk posed by each animal to humans. We also found that the participants' self-declared phobias, as well as their age and geographic region of residence, influenced their decisions. These findings underscore the complex relationship between inherent ecological danger and socio-cultural influences in shaping human perceptions of wild animals.

Our results revealed frequent and quick association between crocodilians and fear. The highest-ranked image portrayed a saltwater crocodile with prominent teeth (Figure 2), which may have bolstered reactions. Indeed, triangular teeth are danger signals that are known to trigger specific reactions (Souchet & Aubret, 2016). Nevertheless, our study participants considered crocodilians scarier than large carnivores that also sometimes displayed their triangular teeth. This result corroborates another study showing that crocodiles formed a distinct group in fear analysis, triggering the most intense fear compared with other legged reptiles while evoking neither beauty nor disgust, unlike snakes (Janovcová et al., 2019). In natural situations, large crocodiles can represent a serious threat (Das & Jana, 2017; García-Grajales & Buenrostro, 2019), yet they remain neglected in experimental studies measuring fear reactions to dangerous animals in humans and non-human primates in comparison with snakes for instance (Zeller et al., 2022).

Apart from a potential teeth effect, the level of dangerousness was a good predictor of the probability to be selected and of decision time. Indeed, participants were more likely to rapidly select a predator appearing in a match. Participants rationally associated dangerous animals, such as the Gaboon viper, with the fear of being killed or injured. They also associated predators like the tiger with the fear of being eaten. These results align with the definition of fear as an adaptative emotional state prompting animals to react in response to threatening and potentially harmful stimuli (Adolphs, 2013).

The broad range of animal species used in our survey revealed that being a predator or a dangerous animal is not sufficient to explain fear. For instance, spiders ranked high on the fear scale even though only 0.5% of all spiders are classified as potentially dangerous (Hauke & Herzig, 2017). Besides, only harmless species of arachnids were included in our study. Other harmless animals, such as bats and lizards, reached higher probabilities to be selected during matches compared with dangerous animal groups, such as felids, hyenas or bears. As suggested by Rudolfová et al. (2022), this fear of harmless spiders might stem from an innate fear of chelicerates, leading to a generalisation of spider fear across all species, whether venomous or not. However, recent studies have not supported this hypothesis (Landová et al., 2023). Instead, misconceptions about spiders, a lack of biological knowledge and feelings of disgust may explain why many people fear spiders (Arntz et al., 1993; Gerdes et al., 2009; Vetter, 2009). In our survey, a majority of participants who selected a spider as the most frightening animal were afraid of being injured, some of them feared to be killed, and a few even feared to be eaten by the spider. Many mistakenly believe that spiders frequently kill humans, indicating an exaggerated perception of the risks associated with them: while humans and primates sometimes eat spiders, the reverse does not occur (Egler, 1992; Iwamoto, 1982; Meyer-Rochow, 2005; Pickett et al., 2012). This rationale can also be applied to dangerous animals, such as snakes: while more than five million people are bitten by venomous snakes annually, resulting in approximately 100,000 deaths (Adukauskienė et al., 2011), snakes are killed and sold on markets for human consumption, medicinal and religious purposes, in Asia, Africa and South America (Alves & Filho, 2007; Cao et al., 2014; Klemens & Thorbjarnarson, 1995). Similar to spiders, snakes are often subject to strong misconceptions and irrational beliefs, a general lack of knowledge and feelings of disgust (Ali et al., 2017; Fernandes-Ferreira et al., 2012; Kaishauri & Makashvili, 2013).

Irrational fears associated with these misconceptions can be transmitted very efficiently among humans. There is evidence that negative parental attitudes and behaviour towards animals influence the level of animal fear and phobia in children (Soga et al., 2020). This may well explain the high probability for arachnids to be selected by young children during image matches, compared with older individuals more likely to select dangerous animals, such as crocodilians. Bats, meanwhile, may have suffered from the timing of the online survey, as 2020 saw the start of the COVID-19 pandemic, which reinforced negative attitudes towards bats due to misinterpretations of the relationship between bats and the origin of the virus widely relayed by various media (Lu et al., 2021; MacFarlane & Rocha, 2020). Furthermore, bats have always been associated with negative superstitions, such as consumption of human blood in Western culture (Prokop et al., 2009). Transmission through media indeed plays a significant role in fostering negative emotions towards specific species. For example, news media often use sensationalised language and graphic content to portray certain animals as dangerous, inducing negative feelings and attitudes towards them (Bombieri et al., 2018; Le Busque et al., 2019). Films contribute significantly to the development of unrealistic biological and ecological misconceptions about animals, which might further perpetuate the fear these wild species evoke in the general public, particularly in children (Henderson & Anderson, 2005; Le Busque & Litchfield, 2023).

We observed slight differences across geographical regions, highlighting the importance of accounting for the potential interaction between ecological and cultural context in shaping perceptions of wild animals in humans. For instance, participants from Asia, where the consumption of scorpions, spiders and other arthropods is more common than in other parts of the world, showed a lower probability of selecting arachnid images compared with participants from Europe (Costa-Neto & Grabowski, 2021). We also found geographic differences for pythons and boas, which were more likely to be selected in Asia than in North America, possibly because of the very rare instances of large pythons killing and eating humans in Asian and African countries (De Lang, 2010; Headland & Greene, 2011). In contrast, we found no differences in the probability of crocodilians to be selected between African and European participants, even though crocodilian attacks are frequent in African countries (Dunham et al., 2010; Eustace et al., 2022), while there is no wild crocodilian in Europe. Although our study accounts for geographical differences, we did not directly collect data on participants cultural backgrounds, and linking geographic regions to specific cultural contexts requires caution to avoid generalisations and oversimplifications of the complex interplay between local beliefs and animal perceptions within and across specific regions. Nevertheless, it is likely that folklore and local beliefs contributed to the observed differences. For instance, cultural narratives surrounding snakes in Ghana, spiders and insects (e.g. praying mantis and earwig) in Nepal or the Aye-aye (*Daubentonia madagascariensis*) in Madagascar, have been shown to influence perceptions and attitudes towards these animals (Attuquayefio, 2004; Gurung, 2003; Randimbiharinirina et al., 2021). Note that our survey was highly biased towards particular geographical regions and audiences (i.e. a majority of Western Europeans with a university degree, internet access, and whose main interests revolve around nature and animals; Online Resource 1, Table S1). Future research that further expands the geographic and socio-cultural sampling beyond WEIRD (Western, Educated, Industrialized, Rich and Democratic) societies could reveal greater complexity in people's responses (Henrich et al., 2010). Online internet survey is a powerful (more than 17,000 people responded to our survey given us strong statistical power in the analysis) and promising tool for measuring human perception of biodiversity (see also Langlois et al., 2022), albeit further research, notably interdisciplinary field research integrating biological and ethnographic methods within a unified conceptual framework (Soga & Gaston, 2022), is needed to better understand the positive and negative perception of specific animals at a finer population level across various geographical regions.

In conclusion, social and cultural transmission of fear of both harmless and dangerous animals across generations is a plausible mechanism likely to explain our results, especially in heavily altered environments where human–nature interactions are minimal and animal threats are inaccurately assessed (Soga et al., 2023). While fears of genuinely dangerous animals are understandable from an evolutionary perspective, the persistence of irrational fears towards mostly harmless species in humans highlights the powerful influence of local and indigenous knowledge, beliefs, misconceptions and socio-cultural transmission (Soga & Evans, 2024). Animal phobias, or more generally biophobia, is one of the most common phobias, increasing in prevalence and intensity, most notably in urban populations (Correia & Mammola, 2024). Media sensationalism and unrealistic portrayals in films exacerbate these fears, especially in children, perpetuating a vicious cycle of biophobia (Soga et al., 2023). This growing global issue not only impacts human health but also hinders conservation efforts, particularly for less charismatic species (Catapani et al., 2024; Gish et al., 2024; Mouquet et al., 2024). Addressing biophobia would require breaking this cycle and reinforcing human–nature connectedness through direct, positive experiences with wildlife, such as nature-observation activities, leading to a virtuous cycle driven by a sustainable worldview (Barragan-Jason et al., 2022; Kos et al., 2023). Such interactions could foster a healthier relationship with nature, benefiting both human well-being and animal conservation initiatives (Marselle et al., 2021; Soga & Evans, 2024).

AUTHOR CONTRIBUTIONS

Xavier Bonnet and Nicolas Mouquet: original idea. Xavier Bonnet and Karl Zeller: selection and collection of photographs; conception of the questionnaire. Nicolas Mouquet and Karl Zeller: online editing and management of the questionnaire; data collection and data management. Karl Zeller: statistical analyses; conceptualisation and writing of the first version of the manuscript. All authors contributed to the elaboration of the research questions, the methodology as well as the questionnaire and online survey design, contributed to the writing and improvements and approved the submitted version.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

The four translations of the survey, the complete database, the classification of the species used and the script for all statistical analyses are available in an institutional online repository (Data.InDoRES) at: https://doi.org/10.48579/PRO/BZZKSG.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Table S1. Information about the participants gathered with the personal anonymized questions during the second part of the survey ($N = 17{,}353$ participants).

Table S2. List of the statistical analyses implemented to test our predictions.

Table S3. Credits of the silhouettes used on the graphs downloaded on the website Phylopic version 2.0 (https://www.phylopic.org/).

Table S4. Median predicted probabilities for a picture to be selected (i.e. the Picture 2) during picture matches along with the 95% quantile credible intervals (highest posterior density interval) for each category.

Table S5. Median predicted probabilities for a picture not to be selected (i.e. the Picture 1) during picture matches along with the 95% quantile credible intervals (highest posterior density interval) for each category.

Table S6. Median predicted probabilities for a picture (i.e. the Picture 2) to be selected during picture matches along 95% credible intervals (highest posterior density interval) for each danger level of the two pictures in a match.

Table S7. Median decision times and 95% credible intervals (highest posterior density interval) of the predicted values distribution of each category as the winner (picture selected during a match).

Table S8. Median decision times and 95% credible intervals (highest posterior density interval) of the predicted values distribution of each category as the loser (picture not selected during a match).

Table S9. Median decision times and 95% credible intervals (highest posterior density interval) of the predicted values distribution of each danger level as the winner (picture selected during a match) and as the loser (picture not selected during a match).

Table S10. Median predicted probabilities for a picture (i.e. the Picture 2) to be selected during picture matches along 95% credible intervals (highest posterior density interval) for each geographical region of the participant.

Table S11. Median predicted probabilities for a picture (i.e. the Picture 2) to be selected during picture matches along 95% credible intervals (highest posterior density interval) for each sex of the participant.

Table S12. Median predicted probabilities for a picture (i.e. the Picture 2) to be selected during picture matches along 95% credible intervals (highest posterior density interval) for each age class of the participant.

Table S13. Median predicted probabilities for a picture (i.e. the Picture 2) to be selected during picture matches along 95% credible intervals (highest posterior density interval) for each self-reported animal phobia of the participant.

Table S14. Median decision times and 95% credible intervals (highest posterior density interval) of the predicted values distribution of each age class of the participant.

Table S15. Median decision times and 95% credible intervals (highest posterior density interval) of the predicted values distribution of each match number.

Text A. Explanations of the two categorizations of the 184 species of the first part of the survey.

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