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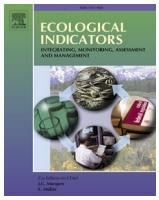

Perceptions and attitudes to understand human-wildlife conflict in an urban landscape – A systematic review

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ABSTRACT

Managing human-wildlife conflicts (HWC) in human-dominated habitats is an important issue in wildlife conservation. Understanding and addressing local people's attitudes and behaviours toward HWC is thought to be imperative for successful human-wildlife co-existence. Despite substantial research and conservation resources being invested to study, protect, and manage HWC globally, research on human perceptions of wildlife is mostly done in silos. Realising the lack of scholarly investigations that focus on such conflicts in urban areas by including perceptions of urban residents, we have made the first step, through a systematic review, to identify progress, gaps and future directions of urban wildlife conflict research. Reviewing all studies published globally (n = 124), we identified nuisance urban wildlife and associated conflicts reported by human residents. The findings revealed that most studies, largely focusing on mammals, were conducted in North America. Based on diet, among the 165 trophic groups studied, the majority were omnivores (n = 67), closely followed by carnivores (n = 50) and herbivores (n = 40). Within vertebrate taxa, bear species (brown, black and sloth bear; *Ursus* spp., *Melursus ursinus*) were the most conflictual followed by grey wolf (*Canis lupus*) and coyote (*Canis latrans*). The lack of longitudinal research to understand the trends and shifts in urban wildlife population and changes in human perception and attitudes was a key finding. Therefore, if research is not supplemented by long-term follow-up studies, the resolution of HWC in urban areas will be under evaluated. Furthermore, researchers should consider integrating quantitative and qualitative research methods, such as in-depth or focus group interviews, to understand motivations or perceptions to present a holistic picture for urban wildlife conservation. Perceptions may shift over time, and the human dimension of wildlife may serve as an ecological indicator of ecosystem status, providing valuable insight into how management measures will be accepted by citizens, which is critical for their success.

1. Introduction

More than 4 billion humans reside in urban areas representing 55% of the global population (Ritchie and Roser, 2018). Moreover, in the next 30 years, this proportion is set to increase to 68% with an estimated global increase of 1 million urban dwellers every 10 days (Acuto et al. 2018). This will inevitably involve further expansion of urban landscapes, creating more opportunities for interactions between humans and wildlife (McKinney 2008; Seto et al. 2012; Magle et al. 2019).

Human interactions with wildlife have undergone changes in nature and intensity through time and space (Magle et al. 2019). However, the lack of space for wildlife caused by rapid urbanisation increases human-wildlife encounters. (Soulsbury and White, 2015). Most encounters between humans and wildlife are either neutral or positive. However, negative interactions do occur, and they can result in a variety of outcomes (for example, costing people money up to species extinctions or loss of human life). Therefore, any such interaction that generates a negative outcome for either humans or wildlife or both is termed human-wildlife conflict (HWC) (König et al., 2021). Such conflicts intensify when there is a competition for similar resources by humans and wildlife (König et al., 2021). These human encounters with wildlife are, for example, observed in vehicle collisions with wildlife (Found and Boyce, 2011; Hussain et al., 2007), wildlife attacks on pets (Bombieri et al., 2018) and damage to lawns and backyards (Basak et al., 2020;

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Tollington et al., 2019). As a result, all such human-wildlife encounters spark a new line of research avenue into how people feel about coexisting with wildlife in cities.

Although wildlife have been in cities for millennia (Soulsbury and White, 2015), systematic research on urban wildlife in cities began only in the 1970 s (Magle et al., 2012) and cities became regarded as unique ecosystems (Collins et al., 2021; Forman, 2016; Gallo et al., 2017). This is because urban ecosystems and their wildlife gradually became a novel base for studying the challenges, opportunities, and solutions that humans face to exist with wildlife (Collins et al., 2021).

As such, it is important to understand the relationship between people and wildlife, which is neither simple nor constant. Human perceptions of wildlife cover multiple states from appreciation to fear, or even hatred, sometimes simultaneously. Although some urban dwellers are enthusiastic about observing wild animals in cities, others may be indifferent or afraid (Elliot et al., 2016). There are also differences in acceptance between charismatic species for e.g., raptors (Hunold, 2017), and other 'unloved' ones for e.g., reptiles, where respondents had different attitudes (both positive and negative) irrespective of snakes being venomous (Kontsiotis et al., 2022). There are certain polarising species (e.g., raccoons *Procyon lotor*) that are simultaneously beloved and despised, and further complicates urban wildlife management (Luther, 2013). Therefore, understanding how people and communities perceive wildlife is a key part of understanding and dealing with potential HWC situations in urban areas (Soulsbury and White, 2015).

Consequently, the first step toward managing conflicts and promoting co-existence is understanding the perception and attitudes of people toward wildlife (Treves and Bruskotter, 2014). Bennett (2016) defined perception as 'the way an individual observes, understands, interprets, and evaluates a referent object, action, experience, individual, policy, or outcome'. However, it should also be acknowledged that perceptions are not based solely on personal experience, but also on a myriad of other factors such as past experiences of similar events that shape the way an individual perceives conflicts along with individual and collective attributes (e.g., gender, race), values, norms, beliefs, preferences, knowledge, and motivations that mediate and influence perceptions (Dickman 2010). On the other hand, attitudes can be defined as the culmination of thoughts, feelings, or opinions about a particular object or personal experiences (Perry et al., 2022). An attitude is also considered to be positive or negative thoughts, feelings, or behaviours about something (Almeida et al., 2014).

The role of urban residents must be understood as they provide valuable information on the perception and attitude towards urban wildlife (Basak et al., 2022), which can guide towards wildlife management in cities. Understanding and addressing local people's attitudes and behaviours toward HWC is imperative for successful human-wildlife co-existence. Therefore, researchers must take advantage of increasing urban residents by engaging them in research with public-policy implications (Soulsbury and White, 2015), especially involving wildlife that exist on human-dominated landscapes (Behr et al., 2017). Generally, in ecology, the quality, capacity and the strategy of research increases when the views of cross disciplines and stakeholders are considered (Evely et al., 2010). For example, when social science methodologies including qualitative or quantitative surveys additionally focus on sociodemographic and ethnographic factors, it further improves the identification of key issues for targeted stakeholders (Maas et al., 2021; Penvern et al., 2019). The increasing usage of social surveys in conservation biology is not new (St. John et al., 2014; Wardropper et al., 2021). However, such research in urban landscapes involving urban wildlife is relatively nascent.

It is well recognised that management of urban wildlife involves a mix of researchers, practitioners, policy makers, urban planners together with citizen supports (Collins et al., 2021). Understanding the role human perceptions of urban wildlife is critical for such an interdisciplinary network. Therefore, it is important that practitioners recognise the current state of citizen's attitudes towards urban wildlife to identify whether HWC are worsening or improving and to develop best practices in conflict management and conservation (Apfelbeck et al., 2020). Past studies can help recognise the strengths and weaknesses of research while identifying potential gaps in current work, which in turn will provide direction for future biodiversity conservation within urban areas.

To date, no review has provided a comprehensive and quantitative evaluation of perception studies to understand urban HWC. Here, we adopt a systematic review process to evaluate trends in the use of perceptions and attitudes to understand urban HWC over time, geographic, trophic and taxonomic focus; and we include the identification of gaps where such research is scarce. We performed systematic review to answer two central questions: How were the perception or attitudes of urban residents used to understand urban HWC and, how does the inclusion of citizens' perceptions or attitudes assist in reducing urban HWC? We aim to answer these two questions by categorising the review into three objectives. The first objective was to identify the current global trend of per se perception studies in urban HWC research. The second objective was to determine the correlation between conflictual urban wildlife and the study area. Specifically, we focused on different wildlife taxa (i.e., insects, amphibians, reptile, mammals and birds) and their trophic categories (i.e., omnivores, herbivores, carnivores and insectivores. Finally, the third objective was to identify the recognised conflicts while highlighting research gaps and opportunities for future studies with reference to longitudinal research to reduce urban HWC. The result of our study reveals potential gaps, illustrates strengths and weaknesses of current research using the perception of urban residents, and provides guidance for future urban HWC research in the same field.

2. Methods

2.1. Search key and selection approach

We conducted the systematic review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses, or PRISMA framework using the conservation and environmental management extension (Pullin and Stewart, 2006). PRISMA review protocols provide a transparent way to summarise the literature in a reproducible way and to avoid poor reporting of systematic reviews (Page et al., 2021). This also enables the readers to evaluate the review and its methodology for themselves, rather than relying on the authors' subjective interpretations of the literature.

The scientific literature was identified using Web of Science (WoS) and Scopus, which are still considered the main sources of citation data (Mongeon and Paul-Hus, 2016). Because our goal was to evaluate HWC studies in urban areas through the perception of residents, we restricted our search criteria to studies conducted within these conditions. We focused our systematic review only on primary research articles that integrated human-wildlife conflicts through the perception of residents.

The literature search was conducted in early 2022 using the following search terms: (wildli*) OR (wild animal*) OR (fauna) OR (predator*) AND (human-wildlife conflict*) OR (human wildlife conflict*) OR (human-wildlife coexistence*) OR (human wildlife coexistence*) OR (human wildlife co-existence*) OR (HWC) AND (urban* OR cit* OR town* OR metropolitan OR residential) AND (perception* OR opinion* OR attitude* OR preference* OR view* OR notion* OR feeling*) AND (human* OR people OR resident* OR citizen* OR communit* OR public) screening titles and abstracts. Our systematic reviews were limited to scientific peer-reviewed articles published in English, and the time frame was limited between 1999 and 2021. Even though the research was performed in 2022, the newest paper considered has been published by the end of 2021.

The initial steps of the literature search returned 344 journal articles from WoS and 169 journal articles from Scopus, all of which were retrieved and assessed to avoid duplication. This process resulted in 375 journal articles, which were then assessed manually for eligibility by

screening titles and abstracts as follows. We included or excluded the articles using predefined inclusion/exclusion criteria (Table 1) based on the title and/or abstract. Consequently, 25 articles were excluded, and the remaining 350 journal articles were read in full, after which another 227 articles were excluded which did not meet the study criteria (Table 1). After final exclusions, 124 articles remained from which data were extracted. Fig. 1 represents the literature search and selection process. The list of articles used in the review has been included in Supplementary Information (SI), with a detailed bibliography in Table S1.

2.2. Summary and analysis

For each article, we identified and coded the following seven categories:

i) location (country) of the study
ii) year of study, or first year of study if it was longitudinal
iii) focal conflictual species
iv) conflicts mentioned
v) possible mention of co-existence
vi) lethal or nonlethal measures to control conflicts
vii) whether a longitudinal study was conducted

After reading through all articles and recording specific conflictual species, we subcategorised the conflictual species into taxonomical and trophic levels.

Therefore, the first type of data included the general nature of the study, including spatial coverage and temporal coverage of the study site between 1999 and 2021. There were no studies before 1999 based on our search criteria. Spatial data were processed in ArcGIS Pro 2.9.1. The time frame of publication was classified further into two decades: Decade I (1999–2011) and Decade II (2012–2021). To find the significance difference of number of publications among the decades, a Chi-square goodness of fit test was conducted.

The second type of data included the identification of conflictual species based on the taxa studied in each continent. This was followed by establishing the inter-relational intensity among the three categories namely continents, taxonomical and the trophic level of conflictual species. The nodes in the diagram represent categories such as continents (Africa, Asia, Australia and Oceania, Europe, North and South America), taxonomical level (birds, mammals, insects, reptiles, amphibians) and trophic level (carnivore, herbivore, omnivore, insectivore and mixed types). The nodes captured the relative participation of the categories. The edges on the other hand connect each node and identify the presence of a relationship between them. The frequency of association between each node was denoted by the size of the edge. The analysis was conducted using 'highcharter' (Kunst, 2017) and 'htmlwidgets' (Vaidyanathan et al., 2021) packages in R v4.2.2 (R Core Team, 2020).

The third type of data was derived by identifying the most common conflicts and co-existence mentioned in the studies for which a word frequency query was undertaken. Word clouds are very good indicators of the frequencies of words per text (Welbers et al., 2017) without considering word positions. We extracted words associated with the different conflicts and co-existence that were either explicitly mentioned in the articles or that could be inferred from the results and discussion of the studies. This was done manually by going through each article explicitly and identifying them. The texts were extracted using the 'tidyverse' (Wickham et al., 2019) and 'wordcloud' (Fellows, 2018) package in R v4.2.2. All packages and dependencies were encapsulated at https://github.com/EkaterinaRostovskaya/HWC-review.git.

Table 1
Criteria used to determine inclusion/exclusion of articles for review in the literature.

INCLUSION	
Perception study	The article must be a perception study conducted based on a questionnaire, survey or in-depth interview to understand the perception or attitudes of residents about conflicts with urban wildlife.
Species	Any wild species, including mammals, reptiles, amphibians, and birds, with which residents felt conflict.
Urban Population	The article must be a perception study of residents about wildlife species/population in an urban setting. Articles that compared rural and urban scenarios or suburban and urban scenarios were also included, provided that urban settings were mentioned.
Conflict	Articles must deal with identifying conflict situations with wildlife.
Language	The article must be published in English.
Publication	Must be from a peer-reviewed publication; graduate theses may be included if the quality of the study is appropriate.
EXCLUSION	
Irrelevant	Articles that did not include a perception study through a questionnaire or survey (for e.g., camera trap-based studies).
Species	Non-wild species (e.g., domestic or feral animals)
Nonurban	Articles that do not include a perception study specifically in the urban environment (i.e., studies conducted along an urban–rural gradient may be included but will be excluded if at least one study area is not expressly urban).
Non-conflict	Articles dealing with the identification of non-conflict situations between humans and wildlife in urban environments were excluded.
Review articles	Reviews of the literature or publications were excluded because they were not based on any new case study.
Laboratory study	Articles on human-wildlife conflicts observed in a laboratory setting (for e.g., from faeces of wild animals).
Protected area	Articles carried out in and around protected areas, not exclusively in an urban environment, were also excluded.

3. Results

3.1. Summary of the spatial and temporal scale of perception studies

Our review focused on the 124 articles (Table S1) that examined the perception study of urban wildlife research globally. The country with the highest number of studies was the United States (n = 43, 34.68%), followed by Australia (n = 10, 6.58%), South Africa (n = 9, 5.92%), Japan (n = 8, 5.26%), Canada (n = 8, 5.26%), Sweden (n = 5, 3.29%), Brazil and India (4 = 8, 2.63%) (Fig. 2).

The search results spanned the period from 1999 to 2021. In the ISI WoS and Scopus Complete Collection, there was no perception study of urban wildlife articles published prior to 1999 based on our search key words. The progress of research shown by the overall temporal trend could be grouped into two decades: Decade I (1999–2011), in which 17 research articles were published, with the highest number of publications (n = 4) in 2008 and 2009, comprising ~ 14% of all research articles. However, there were no research articles in 2000, 2002, 2004 and 2005. Decade II (2012–2021) witnessed an exponential growth in urban HWC research publications (n = 107) that included perception studies and represented 86.29% of the publications, an increase of 529% ($\chi 2 = 65.32$, $p < 0.01$, df = 1) in the first decade. The highest number of research articles in Decade II was recorded in 2019 (n = 20).

3.2. Trophic level of taxonomical groups in different continents

In general, 165 species were identified as studied within the included articles across 6 trophic categories: carnivores (n = 50 studies, 30.30%), herbivores (n = 40 studies, 24.24%), omnivores (n = 67 studies, 40.61%), insectivores (n = 1 study, 0.61%), omnivores and carnivores (n = 1 study, 0.61%), insectivores and herbivores (n = 1 study, 0.61%). There were five studies in which the trophic levels could not be identified (3.03%), which included birds (n = 3), mammals and reptiles (n = 1 each). Approximately 83.64% (n = 138) of the studies involved mammals, followed by birds (9.70%; n = 16), reptiles (3.64%; n = 6), insects (1.82%; n = 3) and amphibians (1.21%; n = 2). Fig. 3 shows the

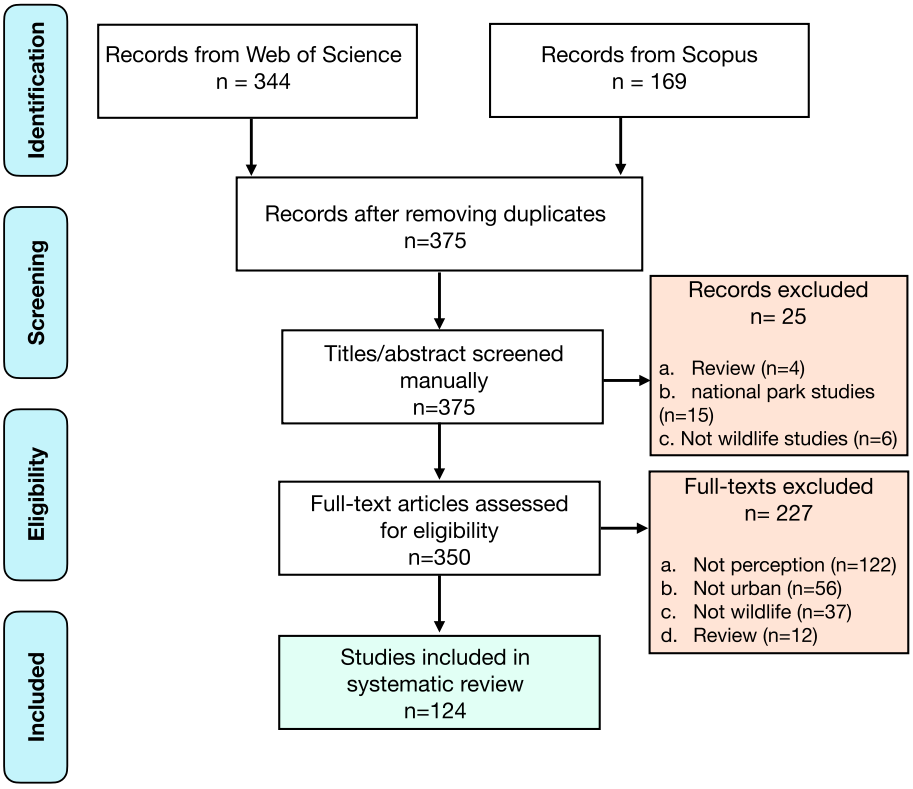

Fig. 1. PRISMA flow diagram showing the procedure that was applied after the literature search (i.e., abstract and full-text screening against inclusion and exclusion criteria, and final included studies for systematic review).

distribution of studied taxonomical group in each continent. The highest number of studies was in North America (n = 72) involving mammals (n = 67), reptiles (n = 3) and birds (n = 2). This was jointly followed by Europe and Asia (n = 30 studies each). In Europe, birds were the second most studied taxa (n = 6) after mammals (n = 22), with only one study each of reptiles and amphibians (Fig. 4). However, in Asia, insect studies (n = 3) followed mammalian studies (n = 25) with one study for each reptile and bird. Of the 15 studies in Australia and Oceania, the majority involved mammals (n = 12), followed by birds (n = 2) and reptiles (n = 1). In Africa (n = 13), there were only studies involving mammals (n = 9) and birds (n = 4). The lowest frequency of studies was in South America (n = 5), for mammals (n = 3), birds (n = 1) and reptiles (n = 1). Out of the 138 mammals being studied globally, 62 studies involved omnivores, followed by 40 and 32 studies of carnivore and herbivore mammals respectively (Fig. 4). Regarding birds (n = 16), the highest number of studies involved herbivores (n = 7), followed by carnivores (n = 3) and omnivores (n = 3).

3.3. Conflict situations with wildlife in different countries

In general, the ten wild species studied the most frequently were bear taxa (*Ursus* spp., *Melursus ursinus*, n = 20); grey wolf (*Canis lupus*, n = 13); coyote (*Canis latrans*, n = 11); deer species (*Odocoileus virginianus, Cervus elaphus*, n = 9); cougar (*Puma concolor*, n = 5) wild boar (*Sus scrofa*, n = 5); red fox (*Vulpes vulpes*, n = 5); macaque species (*Macaca* spp., n = 4); wolverine (*Gulo gulo*, n = 3); and brushtail possum (*Trichosurus vulpecula*) (n = 3). The details on conflictual species in different geographic regions are provided in Table S2.

In the United States, the 43 studies included 56 species out of which 52 were of mammals, 2 studies of birds and 2 of reptiles. There were 6 studies that studied human perception and attitudes toward more than one wildlife species (Black et al., 2018; Hohbein and Mengak, 2018; Kretser et al., 2009; Landon et al., 2019; Nardi et al., 2020; Smith et al., 2014). Among the 52 mammals studied, the majority of the studies involved the identification of attitudes toward coyotes (n = 11), followed by studies of black bear (*Ursus americanus*; n = 6), white-tailed deer (n = 6), cougar (n = 4), grey wolf (n = 6), moose (*Alces alces*), red fox and North American beaver (*Castor canadensis*) respectively (each, n = 2). The two studies of birds included the red-tailed hawk (*Buteo jamaicensis*) and the house sparrow (*Passer domesticus*) while the two studies of reptiles involved understanding human conflicts with the western diamond-backed rattlesnake (*Crotalus atrox*).

Similarly, in the 11 studies in Australia, 12 species were studied, of which 11 were mammals and only one study was in a brown snake (*Pseudonaja* spp). The most common mammal species studied was the brushtail possum (n = 3) closely followed by kangaroos (*Macropus* spp. and *Osphranter* spp.) (n = 2) and long-noosed bandicoot (*Perameles nasuta*) (n = 2).

In the 9 studies conducted in South Africa, 10 species were studied of which 6 were mammalian species and 4 were bird species. The 4 nuisance birds species studies were of African woolly-necked storks (*Ciconia microscelis*), speckled pigeons (*Columba guinea*), rock pigeons (*Columba livia*) and Egyptian geese (*Alopochen aegyptiaca*).

On the other hand, the 8 urban HWC studies in Japan mostly involved mammals (n = 9) such as brown bear (*Ursus arctos*) (n = 3), Asian black bear (*Ursus thibetanus japonicus*) (n = 2), wild boar (n = 2) and Japanese macaque (*Macaca fuscata*) (n = 2).

Similarly, the studies in Canada (n = 8), largely involved mammals (n = 9) similar to Sweden (n = 6), India (n = 3) and Brazil (n = 3). Interestingly, in New Zealand and Slovenia, studies involved perception involving only birds (for example, native parrots *Nestor meridionalis* or hooded crows *Corvus cornix*).

3.4. Conflict, co-existence and conflict mitigation

In terms of conflicts, confrontations related to urban wildlife damaging properties comprised 25% of the total conflicts mentioned; 12.7% focused on danger to human life; 11% dwelt on danger to pets;

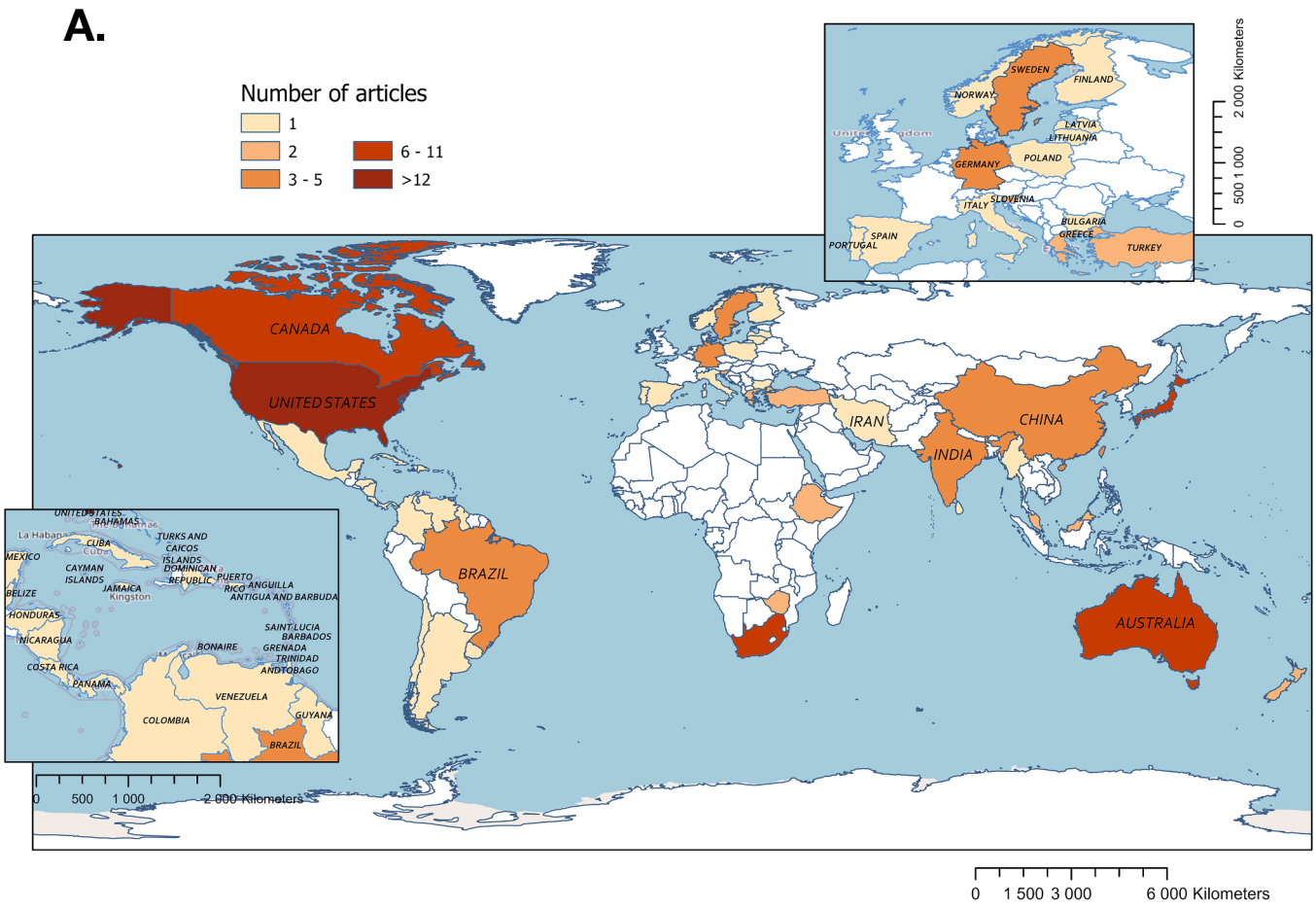

Fig. 2. Geographical distribution of published research within the search criteria.

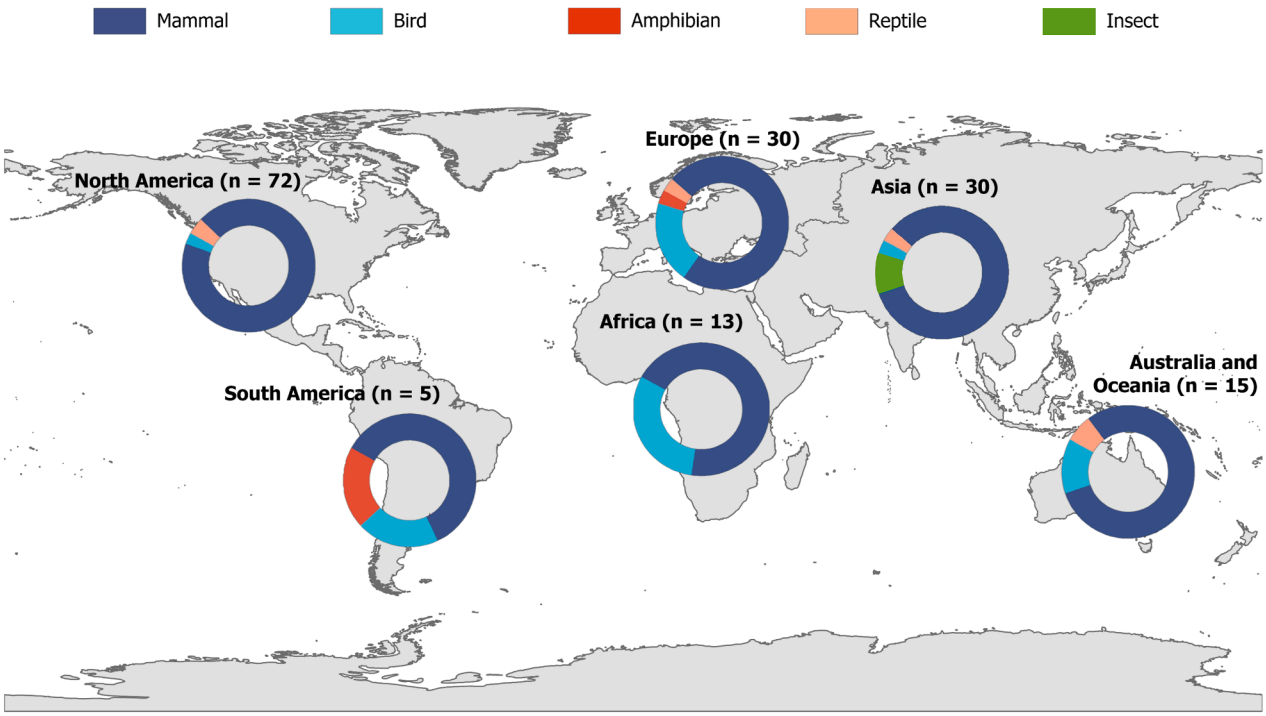

Fig. 3. Geographic distribution of studies based on the taxonomical level.

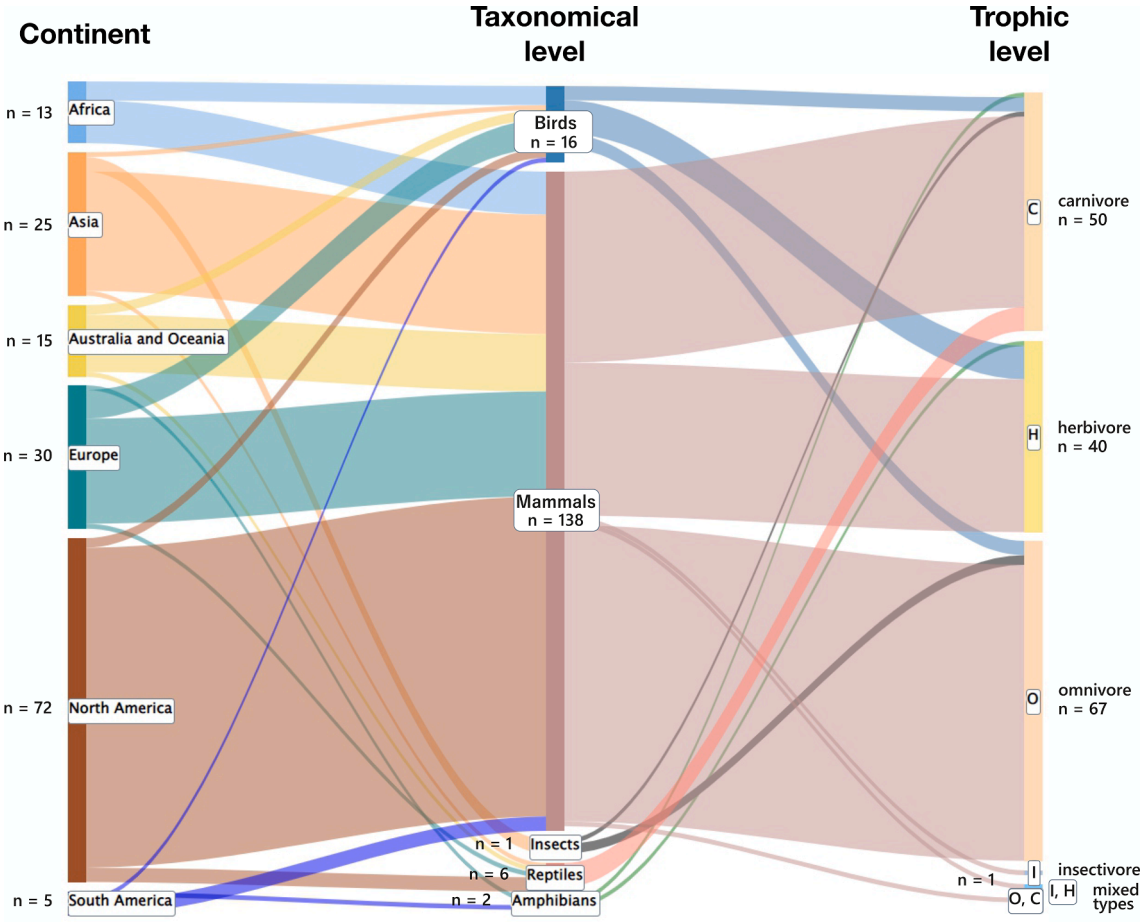

Fig. 4. Trophic and taxonomical groups of studied conflictual wildlife in different continents.

11% of conflicts were diseases; 9% for personal attack or fear for livestock; and finally, almost 6% for fear for children, noise, threats and personal safety (Fig. 5A).

Fig. 5. Word cloud indicating the most common conflicts (A) and co-existence (B) with wildlife.

Around 17 articles either considered co-existence in their survey or respondents advocated for some degree of mutual co-habitation. For example, the most frequent mention of co-existence was the acceptance that wild animals are a part of nature (17%). This was followed by positive emotions of enjoyment and pleasure (each 14%) along with the need to conserve the species (12%) and promote a healthy environment (10%). Additionally, mention was made of urban wild animals as indicators of diversity, affection, acceptance, and value as assets (each 7%) (Fig. 5B). Although most of the positive attitudes favouring co-existence were directed towards birds (Harris et al. 2016), similar attitudes were not uncommon even for carnivore mammals, for example, with coyotes (Draheim et al., 2013) or brown bears (Kubo and Shoji, 2014).

Regarding HWC mitigation strategies, only 22% of the selected literature specifically discussed or recommended these. The most recommended non-lethal methods to resolve conflicts were translocation (Bateman et al., 2021), public education or community conservation (Buteau et al., 2021), maintaining predators to naturally control nuisance wild animals, building fences (Draheim et al., 2019) and deploying guard dogs (Chynoweth et al., 2015).

3.5. Inclusion of longitudinal research in urban wildlife perception studies

There were 7 studies (Booth and Ryan, 2019; Bruskotter et al., 2007; Chynoweth et al., 2015; Hohbein and Mengak, 2018; Jackman and Rutberg, 2015; Kilpatrick and LaBonte, 2003; Lischka et al., 2019) that conducted a longitudinal study investigating people's perception and shift in attitudes towards urban HWC over time. Of the 7 studies, the majority were conducted in the United States (n = 5), followed by Canada and Turkey (n = 1 each). Changes in attitudes towards particular

mammal species (n = 14) were studied with respect to black bear, white tailed deer, wild boar and grey wolves (n = 2 each), and Caucasian lynx (*Lynx lynx dinniki*), coyote, brown bear, mole (*Scalopus* spp.), vole (*Microtus* spp.) and squirrel (*Sciurus* spp.) (n = 1 each). Studies showed that despite regularly encountering large mammals, residents' attitudes were generally positive or improving (Chynoweth et al., 2015), for example, toward black bears (Booth & Ryan 2019) or coyotes (Jackman & Rutberg 2015).

4. Discussion

Despite a steady increase in research over the past decade, our review identifies several persistent knowledge gaps and challenges. In addressing these gaps, measures must focus on future research. For example, more than 80% of the studies involved conflicts with mammals; however, only ~ 5% of the studies involved longitudinal research to detect and understand the change in attitudes of residents. Therefore, this systematic review highlights the urgent need to frame the questions that need to be investigated in the future if HWCs are to be effectively managed or mitigated.

4.1. Urbanisation and its role in wildlife conservation

Urbanisation is known to play a positive role in determining people's value and attitudes toward wildlife (Kansky and Knight, 2014). The public's attitude and tolerance towards wildlife has a large influence on the management of problem-causing animals in cities (Ngo et al., 2019). However, people residing in cities have positive attitude towards wildlife as they have few childhood exposure and life-threatening encounters with wildlife. For example, in studies conducted in Malaysia (Tan et al., 2020), positive effect of urbanisation was found on people's attitudes towards wildlife or that people from urban areas expressed more favourable attitudes towards elephants than their rural counterparts (Sampson et al., 2021). However, contrary to popular belief that positive attitudes of urban residents is only towards less conflicting wildlife such as squirrels (Bjerke and Østdahl, 2004; Mohamad Muslim et al., 2018) or birds (Schlegel and Rupf, 2010), is often not true. The presence of carnivores such as black bears (Booth and Ryan, 2019) or coyotes (Jackman and Rutberg, 2015) was supported by urban residents, and attitudes toward carnivores such as grey wolves did not change over time (Bruskotter et al., 2007). On the other hand, the constant presence of certain wildlife in urban landscapes decreased fear over time (Jackman and Rutberg, 2015). This frequent observation of wildlife boosted tolerance levels and increased the disapproval of lethal methods to control conflicts. In a study in the USA (Lute et al., 2020), non-lethal self-action was preferred in controlling conflicts with coyotes or wolf reintroduction was encouraged (Booth and Ryan, 2019). Thus, although less tangible, urbanisation has produced some socio-economic changes (e.g., education, awareness, wealth) that have redefined the values of wildlife (Chardonnet et al., 2002), serving as the basis for constructing more wildlife-friendly institutions and policies. The increasing recognition of the importance of participation of stakeholders in environmental decisions has led to several attempts to implement their participation in decision making (König et al., 2020).

4.2. Knowledge gaps and impact of the shortfall

Generally, urban planning does not typically consider the need for wildlife (Apfelbeck et al., 2020), although many species of wildlife can thrive and use the habitats provided by cities (Magle et al., 2019). Simultaneously, we are aware that in recent years, the shrinking of the natural habitat is forcing wildlife species to colonise urban areas (Smith et al., 2014). However, wildlife management is for many cities a low priority, carried out by multiple municipal agencies with conflicting missions and messaging regarding the disposition of wildlife (Hunold, 2017; McCance et al., 2017). This calls for further research in this domain to understand the context and changing dynamics of HWC in urban areas. Although there have been an increasing number of studies focused on urban wildlife (Egerer and Buchholz, 2021; Zellmer and Goto, 2022), yet such studies on urban wildlife ecology also have limitations (Magle et al., 2019).

Our review revealed specifically two knowledge gaps where future research could be supplemented. Firstly, one of the most limiting aspects of urban wildlife research is studies conducted on single species or of short duration (Magle et al., 2019). This research gap can be supplemented with long term or longitudinal studies by identifying changes over a longer period, allowing for stronger conclusions (Basak et al., 2022). One of the most conspicuous knowledge gaps we identified based on our results is the lack of studies that had any longitudinal approach to understand urban human-wildlife conflicts. For example, only ~ 5% of the studies (n = 7) involved any longitudinal research to understand the change in attitudes of residents, with majority being conducted in the United States (n = 5). The lack of long term studies conducted worldwide is appalling considering the call for such research is not new, particularly in Asian countries (de Silva, 2016) Therefore, if research is not supplemented by long-term studies, the transition or transformation of HWC in urban areas will be less understood. Longitudinal studies are not only a prerequisite for understanding urban wildlife population trends and shifts in human perception and attitudes, but they can be extended to understand the changing context of HWC in urban areas. For example, the longitudinal study by Lischka et al., (2019), reported that respondents to the survey experienced at least some nuisance-related conflicts with bears in the previous 2 years, yet majority reported at least one positive impact from their interactions with bears. Similarly, another long tem study by Jackman and Rutberg, (2015) reported that respondents were more accepting of coyotes in over the span of seven years (between 2005 and 2012), with fear and acceptance of lethal management actions having decreased concurrently with coyote acceptance. Thus, an important finding of our research is that without the temporal components included in research, one is left with snapshots that give no indication of whether HWC are worsening or improving, or how urban wildlife are changing and adapting.

However, this dearth of longitudinal studies in conservation biology extends even to protected areas where it was realised that studies spanning even a few years can be highly informative about the adequacy of extant protected areas, management plans, or risky locations acting as population sinks (de Silva, 2016). Although mitigation methods are generally applied by wildlife managers, there were few studies that not only systematically evaluated conflicts but also conducted follow-up research with stakeholders affected by such conflicts (de Silva, 2016). Therefore, once conservation interventions are conducted, efficacy must be evaluated, and subsequent actions must be modified accordingly. Even though it cannot be ignored that longitudinal studies raises both time and financial issues (Caruana et al., 2015), there is a need to encourage a shift in decision-making about funding to facilitate better research in the future. Conservation biology has been criticized for lack of rigor in doing so compared to other disciplines with similar applied aims, such as medicine (Pullin and Stewart, 2006); so, unless we overcome this issue of follow-up studies, the discipline will remain deficient in crucial respects.

The second shortfall that was identified from our study was the greater use of questionnaires by studies in North America or in Australia than in any parts of the world, suggesting a geographical bias in methods used for the management of problems in ecology. This also explained the reason behind majority of conflictual species being described predominantly based in North America and Australia (Fig. 4). It was observed that there is greater involvement of the general public or stakeholders in decision-making in ecology in North America than elsewhere, be it in terms of conflicts management such as the managing coyotes in urban landscapes (Wilson and Rose, 2019) or black bears (Lischka et al., 2019). People in general, are becoming more interested in participating in decision-making on wildlife issues (Chase et al. 2004), which in turn

makes the management being driven by societal perceptions of wildlife conflicts. Therefore, we suggest that these geographical biases of questionnaire-based studies could be reduced by wider applications in the near future. However, large-scale questionnaires or surveys may not be effective in some parts of the world, or for answering all research questions (Einola and Alvesson, 2021). In those scenarios, an alternative such as in-depth interviews with strong qualitative components (Einola and Alvesson, 2021) with certain stakeholders could supplement in understanding the changing nature of urban HWC. One strategy in improving understanding of such a phenomenon is the application of mixed methods in a way that avoids making limiting methodological decisions and permits the simultaneous and comprehensive use of both quantitative and qualitative approaches. Furthermore, the sociodemographic characteristics of actors should be considered, as such characteristics often determine perceptions toward any species (Cortés-Avizanda et al., 2022). For example, women are more concerned than men about the well-being of wildlife in the natural environment (Chauvat et al., 2023; Graça et al., 2018) or that younger people are more affectionate toward animals than older people (Cronin et al., 2022; Kellert, 1993).

4.3. Opportunities and recommendations for urban human-wildlife studies

In an increasingly populated world, where wildlife habitats are being converted to human uses at an increasing rate and wildlife movement corridors are being narrowed or cut off by infrastructure and other developments (Zellmer and Goto, 2022), forcing wildlife to retreat into habitats that are becoming more and more fragmented, it is crucial to use holistic and integrated approaches to manage the human-wildlife interface (Gross et al, 2022). In general, one needs to use caution while taking into account local residents' perspectives on handling wildlife. People base their perceptions and attitudes not only upon facts and personal experiences, but also upon a myriad of factors such as wider societal experiences, cultural norms, expectations and beliefs over time. These social factors can play an extremely important role in HWC, yet are relatively rarely considered (Dickman 2010). Researchers all over the world are studying the human dimensions of wildlife management while acknowledging that higher perceived risk toward wildlife can, in turn, reduce the number of people who value conservation (Kimmig et al., 2020). Urban residents can provide valuable information on the diversity and abundance of local wildlife (Basak et al., 2022). As a result, researchers must capitalize on the growing number of urban residents by engaging them in research with public-policy implications (Soulsbury and White, 2015), particularly involving wildlife found on urban landscapes. (Behr et al., 2017).

Nevertheless, future HWC researchers should understand that even though a large number of urban residents could become involved in such studies, defining a target population is always recommended. Explicitly stating target sampling procedures for the selection of participants should be well-documented and justified (Martínez-Mesa et al., 2016; Palinkas et al., 2015). While conducting social surveys such as questionnaires, should be pre-tested by piloting on a subsample of participants which negates any potential problems caused by misunderstandings (Bowden et al., 2002). Finally, the sample size (number of respondents) should be sufficient to yield robust data (White et al., 2005). Traditionally, conservation biology has focused on the analysis of factual information. However, with the increasing importance of stakeholder perceptions and greater inputs of diverse interest groups into policy-making decisions for the management of ecological resources, ecologists will need to embrace more diverse paradigms. Furthermore, the inclusion of focus group discussion (Nyumba et al., 2018), ethnographic research (Setchell et al., 2017) and participatory methods (Buchs et al., 2021) in ecological research would enhance applied ecological research. The amalgamation of quantitative and qualitative approaches in conservation science, although challenging (White et al., 2005), must be used to obtain a holistic picture for urban wildlife conservation involving public-policy implications.

5. Conclusions

Our review revealed that an understanding of public attitudes toward urban wildlife is critical in obtaining wide support for biodiversity conservation in urban areas. Perceptions may change over time, and the human dimension of wildlife might serve as an ecological indicator of ecosystem status, giving valuable clues on how management measures will be accepted by urban populations, which is essential for their success. Therefore, engagement of local stakeholders (e.g., inhabitants, administration bodies, policy makers) forms a crucial link to a better understanding and appreciation of urban wildlife. We must maintain efforts to collect baseline data for urban wildlife of concern so that shifts can be detected and used as the foundation for scientifically informed management. Furthermore, collaboration between disciplines and sectors is necessary to evaluate and manage complex human-wildlife interactions (König et al., 2020). Collaborations, for instance, might involve professionals in conservation, community leaders, governments, researchers, companies, and other stakeholders by integrating knowledge of ecology, social psychology, economics, peacekeeping, environmental and political law (Hodgson et al., 2022). Finally, to help policy makers and practitioners adapt to the changing land use brought on by growing urbanization in the future and to create a landscape that allows for both people and wildlife to coexist, longitudinal studies would become indispensable. There may be pressures for "fast remedies" to HWC, especially in an urban context, but solutions that fail to consider local and broader societal contexts might have unforeseen reparations and raise tensions. While there are many established sites for conducting ecosystem-level longitudinal research, there are few explicitly longitudinal initiatives focused on human perception study on urban wildlife. It's time we have a shift towards this paradigm.

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

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