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# Global review of services and conflicts provided by raptors in urbanized habitats

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**Abstract**
In an increasingly urbanized world, some raptors successfully colonize and thrive in urban environments, leading to more frequent interactions with humans. These interactions can be either positive, such as providing ecosystem services, or negative, resulting in human-wildlife conflicts. Despite growing literature on these interactions, a comprehensive review focusing on urban environments has been lacking. This study aimed to address this gap by conducting a systematic review using Google Scholar and the Scopus bibliographic database. A total of 45 studies met the search criteria, with a predominant prevalence of the northern hemisphere. Accipitriformes was the most studied order of raptors (50%), followed by Strigiformes (37%), Falconiformes (8%), and Cathartiformes (2%). Positive interactions studied included cultural services, pest control, positive perception, carrion removal, while negative interactions involved safety damage, property damage, negative perception, disease transmission, livestock damage, nuisance and superstitions. Pest control and cultural services were supported by the evidence, although only for specific orders. Carrion removal and aggressiveness appear to decrease with urbanization, although more studies are needed to verify this premise. Both positive and negative perceptions were evident, influenced in part by the knowledge or closeness that people had towards urban raptors. We discuss how the interactions studied influence the daily lives of citizens and, in turn, how human activities shape and influence these interactions. Finally, given that cities are socio-ecological systems, we advocate for methodologies that integrate the social aspects of human-predator interactions along with ecological ones to promote coexistence.

**Keywords** Urban raptors · Ecosystem services · Human-wildlife interactions · Human-wildlife conflicts · Bird of prey · Urban ecosystems

## Introduction

In the modern world, the rate at which human populations and land cover are becoming urban is faster than at any other time in history (Seto et al. 2010). Indeed, urban land cover is expected to increase between 430.000 km$^2$ and 12.568.000 km$^2$ (Seto et al. 2011) and global population is expected to increase to 8.5 billion (from 7.7 billion in 2019) (United Nations Development Programme 2022) by 2030. Although the expansion of urban lands on rural and natural lands generally has negative consequences for biodiversity (Piano et al. 2020), some species, such as birds, are able to colonize, persist or even thrive in urban environments (Isaksson 2018). In fact, some urban areas have greater abundance of birds (or biomass) per sampling unit than nonurban habitats (Marzluff et al. 2001; Chace and Walsh 2006; van Rensburg et al. 2009; MacGregor-Fors et al. 2012; Drewitt et al. 2021). Particularly, raptor exemplify this phenomenon, with some species becoming increasingly common in urban areas due to their ability to exploit nesting and feeding opportunities available in cities (Bildstein and Therrien 2018; Mak et al. 2021) (e.g., Great Horned Owl *Bubo virginianus*, Peregrine Falcon *Falco peregrinus*, Black Sparrowhawk *Accipiter melanoleucus* and Black Kite *Milvus migrans)* (Chace and Walsh 2006; Suri et al. 2017; Mazumdar et al. 2017; Kettel et al. 2018). While cities can be ecological traps for some raptor species (Sumasgutner et al. 2014; Kettel et al. 2018),

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they also act as population sources for other species, such as Peregrines in the United Kingdom, which may help recolonize vacant territories (Drewitt et al. 2021). Furthermore, as previously observed for threatened species (Ives et al. 2016), cities can serve as conservation hotspots for raptors like Burrowing Owls (*Athene cunicularia*) (Rebolo-Ifrán et al. 2017). These species are now faring better in moderately urbanized areas than in their increasingly threatened natural habitats (Rebolo-Ifrán et al. 2017; Franco and Marçal-Junior 2018; Baladrón et al. 2020; Cavalli et al. 2023).

The increase in raptor populations in cities, coupled with the expansion of peri-urban environments (transition zones between urban and rural areas that typically exhibit relative higher levels of species diversity and abundance) (McKinney 2002; Seto et al. 2010) heightens the likelihood of human-raptor interactions (Conover 2001, p.33; Ditchkoff et al. 2006). These interactions can range from positive outcomes for humans, such as ecosystem services, to negative ones, like human-wildlife conflicts. Ecosystem services are defined as the benefits people obtain from ecosystems and the species that compose those systems (Millennium Ecosystem Assessment 2005). Ecosystem services that raptors provide might include, scavenging by vultures and other raptors, biological control of pest species (regulating services) and economic and social benefits from bird-watching and ecotourism (cultural services or nature's material contribution to people) (Díaz et al. 2018). On the other hand, negative interactions, usually termed human–wildlife conflict, emphasize the antagonism relationships between wildlife and humans (Conover 2001, p.8; Graham et al. 2005). In this review, we adopt the definition of human-wildlife conflicts provided by Soulsbury and White (2015), which describes these conflicts as situations "… caused where the movement and activities of wildlife, such as those associated with foraging or reproduction, have an adverse impact on human interests…". Such impacts may include aggression, property damage (both livestock and non-agricultural property), disease transmission and nuisance (Peterson et al. 2010; Soulsbury and White 2015).

While global scientific information on human-raptor interactions is increasing, current reviews primarily focus on how these interactions benefit or affect raptors at an individual or population level, such as survival or reproductive success. Most reviews detail interactions occurring in natural or rural settings (Nyhus 2016; McClure et al. 2018; Canney et al. 2022; Ballejo et al. 2022) or concentrate on specific raptor groups (Carucci et al. 2022). Although these studies are valuable and enhance our understanding of human-raptor dynamics, it is crucial to thoroughly examine the progress made in researching interactions that directly and indirectly affect humans, which we focus in this study. Raptors could improve human well-being by connecting people with nature experiences (i.e. green prescribing) (Thomas et al. 2022) and act as flagship species, but they are also more threatened than birds in general (Donázar et al. 2016; Cox et al. 2017; McClure et al. 2018). Since conservation interventions are shaped by human decisions (Mascia et al. 2003), exploring human-raptor interactions, as proposed in this review, is vital for developing more effective conservation strategies and fostering coexistence between humans and raptors. Accordingly, our objective is to review empirical studies of raptor ecosystem services and conflicts, as defined above, with human in urban environments. We quantify and synthesize existing information, identify areas of progress and pinpoint information gaps and biases. Finally, we provide recommendations for future research and management based on our scientific understanding of current human-raptor interactions.

## Methods

We conducted a bibliographic search in English in Google Scholar and Scopus to find peer-reviewed articles on positive and negative human-raptor interactions in urban environments around the world until 1st of June 2023, without year restriction. We define raptor as species within orders Cathartiformes, Accipitriformes, Strigiformes and Falconiformes (Boal and Dykstra 2018). We filtered our search to studies conducted in urbanized environments, which included: cities, suburban or peri-urban areas and villages. Studies comparing natural and rural environments with urban ones were also included in the review. We focus only in those articles that studied natural or spontaneous interactions between raptors and humans; therefore, those that studied the pest control services using falconry were excluded from the analysis. To avoid repetition of information already published in the scientific literature, we excluded gray literature (theses and dissertations), books, book chapters and scientific reviews. Additionally, we discarded duplicate studies. Since we are interested in the human dimensions from interactions, we excluded studies that did not address the human aspect, specifically those did not involve raptors impacting human interests or providing ecosystem services. For example, we excluded studies that solely evaluated conservation issues such as deaths from electrocutions, pollution, intentional killings, agrochemicals, collisions with windows, or those using raptors as indicators of environmental health or as flagship species. An initial search using the keywords "urban raptor" in both digital academic search engines was conducted to cover a wide range of interactions between human and raptors.

Then, we performed a second specific search using the following combination of terms: "urban" OR "city" AND "raptor" OR "bird of prey" OR "predatory birds" AND "conflict" OR "benefit" OR "ecosystem services" OR "human-raptor interaction" OR "diet" OR "control pest" OR "disease transmission" OR "aggression" OR "attack" OR "scavenger" OR "cultural service" OR "garbage". We followed the protocol established for PRISMA Statement (Page et al. 2021) to select suitable records. We also checked the bibliographies of the articles identified in the database search for additional relevant publications that may not have appeared in Google Scholar or the Scopus bibliographic database. For more details on the methodological choices made in the selection of studies for this review, see Supplementary Materials (Fig. S1).

From each selected scientific article, we extracted the year of publication and the country of the study, the species studied, the methodology used (hereafter referred to as "Methodological approach"), the type of interaction evaluated (positive, negative or both) and whether the authors proposed any management measures to mitigate human-predator conflicts. We then classified the articles based on the type of human-raptor interaction studied and the methodology approach used (Table 1). The categories were not mutually exclusive, as a study could use more than one methodology to examine the same interaction or study multiple interactions, both positive and negative. Finally, for each species studied we extracted the conservation status from the IUCN Red List (IUCN 2024). The data were analyzed using R statistical environment (R Core Team 2023) and in SCImago Graphica (Hassan-Montero et al. 2022).

## Results

### Year of publication and geographical areas studied

We identified 45 studies that met our selection criteria. The earliest study was published in 1999, and there has been an increasing trend in the number of studies on this topic over time, with the highest publication rate occurring in 2018 ($n = 7$; Fig. 1). Scientific publications from all continents were found, but the majority were from Asia (27%; $n = 12$) and North America (24%; $n = 11$), followed by Europe and South America (each one 16%; $n = 7$), Africa (11%; $n = 5$) and Oceania (7%; $n = 3$; Fig. 2). In the geographical analysis of the Proportion Z-Test at the continental level (Table SM2), the following significant differences in the proportion of studies on positive interactions were evident: Europe ($z = 2.11$, $p = 0.04$), South America ($z = 2.63$, $p = 0.01$) and Oceania ($z = 2.25$, $p = 0.02$) conducted more studies on

**Table 1** List of categories used to classify positive (modified from Diaz et al. 2018) and negative (modified from Peterson et al. 2010 and Soulsbury and White 2015) human-raptors interactions and methodologies approach implemented in the studies found

| Study divisions | Categories | Description |
|---|---|---|
| Positive interaction | Carrion removal | Removal by obligate and facultative scavengers of animal carcasses and human garbage. |
| | Pest control | Regulation, by raptors, of pests and pathogens that affect humans (materially and nonmaterially). |
| | Cultural service | Raptors serve as the foundation for religious, spiritual, and social cohesion experiences, providing opportunities for psychologically beneficial activities and aesthetic enjoyment derived from close contact with nature, such as birdwatching. |
| | Positive perception | Positive view of raptors due to pest control, carrion removal and economic gains. |
| Negative interaction | Safety damage | Raptor harm to humans and pets. |
| | Livestock damage | Includes damage to livestock, farm animals, or animals used commercially by humans. |
| | Disease carrier | Transmitter or reservoir of pathogenic diseases. |
| | Nuisance | Discomfort caused by raptors due to their daily activity (e.g., noisy behavior, feces, nest building). |
| | Property damage | Damage caused by raptors to any non-agricultural property (e.g. collisions with airplanes). |
| | Negative perception | Negative view of raptors caused due to transmission of disease, nuisance behavior or damage to livestock, humans and pets. |
| | Superstitions | Negative perception of raptors due to superstitions and legends. |
| Methodological approach | Interview | Studies that conducted interviews or questionnaires. |
| | Citizen science | Studies that used information provide from citizen. |
| | Database | Studies that use a database that they did not generate, such as those on armed forces or journalistic news. |
| | Field experiments | Studies that carried out experiments in the field (e.g. carrion deposition to evaluate carrion removal service). |
| | Camera trap | Studies that used camera trap to study diet and pest control. |
| | Microbiological test | Studies that perform swabs and laboratory diagnoses. |
| | Pellet analysis | Studies that examine the pellets to study diet and pest control. |
| | Survey | Studies that census individuals or register their behavior in the field. |

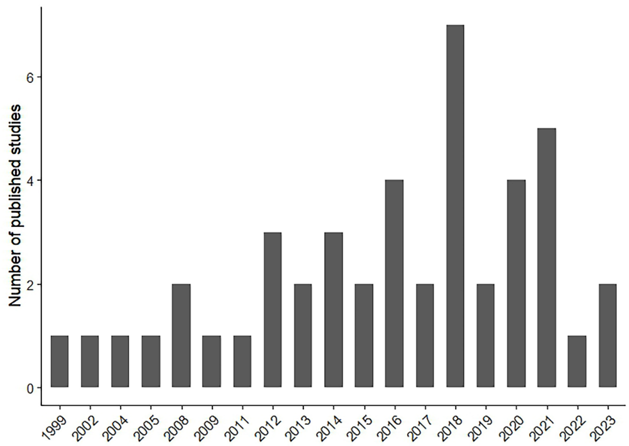


**Fig. 1** Number of published studies of positive and negative human-raptor interactions in urban environments over the years

positive interactions than Asia. South America also had a higher proportion of positive studies than Africa ($z=2.16$, $p=0.03$). Finally, a marginal difference was observed between Oceania and Africa, likely influenced by the low sample size, in favor of Oceania ($z=1.89$, $p=0.05$). Regarding the proportion of negative studies, North America presented a significantly greater proportion compared to Asia ($z=2.81$, $p=0.01$), Africa ($z=2.25$, $p=0.02$) and Oceania ($z=1.94$, $p=0.01$).

The countries with the most registered species were slightly positively correlated with the number of published articles (Spearman test, $r^2=0.53$, $p=0.02$). The United States had the highest number of publications (24%; $n=11$), followed by India (11%; $n=5$). Spain was the country with the most species studied (43%; $n=28$), followed by United States (31%; $n=20$) and India (8%; $n=5$). Additional data of interactions according to country are presented in Supplementary Materials, Table SM1.

## Studied taxa

Some articles investigated the same type of interaction across multiple species, families, or orders simultaneously. Consequently, the sum of studies conducted for each order or family exceeds the total number of studies reviewed ($n=45$). For instance, the most studied Order was Accipitriformes (50%; $n=60$), followed by Strigiformes (37%; $n=44$), Falconiformes (8%; $n=10$) and the least studied Cathartiformes (2%; $n=2$). Adjusting for the total number of species per order reveals that Cathartiformes (29%) emerges as the most studied, followed by Accipitriformes (23%), Strigiformes (18%) and Falconiformes (15%). The total number of species considered for each order was 7 for Cathartiformes, 252 for Accipitriformes, 247 for Strigiformes and 65 for Falconiformes (Billerman et al. 2022). Three studies were not classified by Order because the identification by the authors was labeled as "Raptor or/and vulture". The most studied families were Accipitridae (48%; $n=56$) followed by Strigidae (29%; $n=34$), Falconidae and Tytonidae (each one 8%; $n=10$), Pandionidae (3%; $n=3$) and Cathartidae (2%;

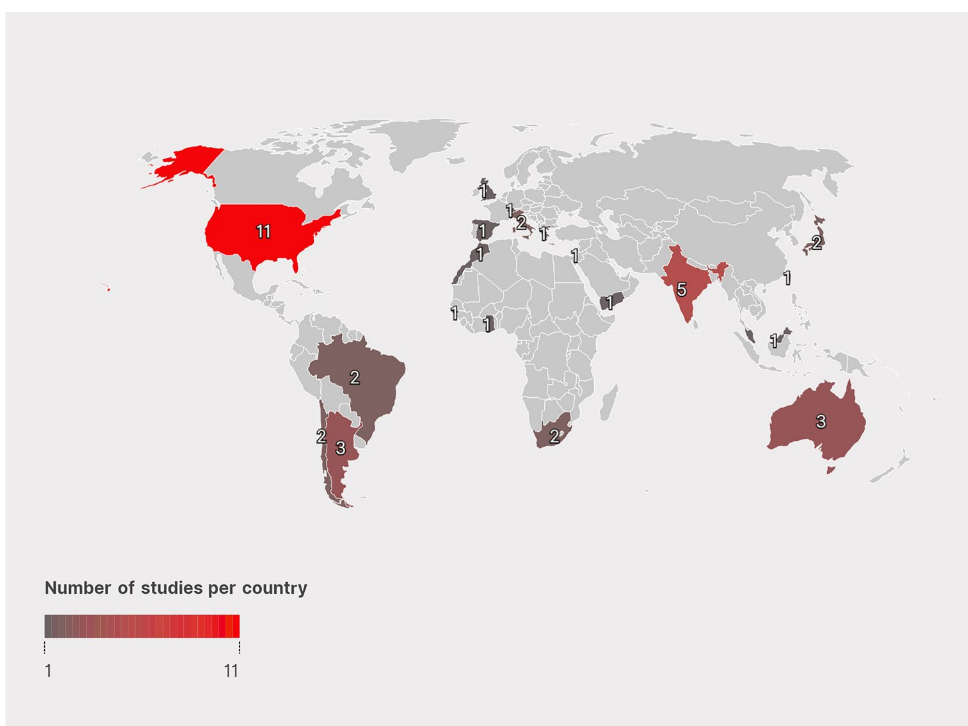


**Fig. 2** Map of the countries were the studies where performed. Bright red shows high number of articles found for a given country, ranging from 1 (dark red) to 11 (bright red). The black numbers within each country indicate the number of studies published in them

$n = 2$). Again, in four articles it was not possible identify the family for the reason exposed above or because the authors identified the species like "Accipitriformes spp.".

The studies record 65 species (Table 2). The most frequently studied species were the Barn Owl (*Tyto alba*) (8%; $n = 10$), followed by the Black Kite (*M. migrans*) and the Peregrin Falcon (*F. peregrinus*) (each one 3%; $n = 4$). Of these species, 15% ($n = 8$) are considered species of conservation concern by the IUCN (Table 2). Only one species (*Strix mauritanica*) was not evaluated for the IUCN. The rest of the species were categorized as Last concern (86%; $n = 56$).

### Methodological approach

The identified studies employed a variety of methodological approaches to examine both positive and negative human-raptor interactions in urban environments. Interviews were the most common method, used in 26% of the articles ($n = 12$), followed by pellet analysis and surveys (each constituting 19%; $n = 9$). Field experiments and database analyses accounted for 10% each ($n = 5$), microbiological tests for 6% ($n = 3$) and camera traps and citizen science each made up 4% ($n = 2$). Methodologies approaches used were not mutually exclusive, as we found studies with multiple methodologies for evaluating the same or different interactions.

### Human-raptors interactions

As some studies selected for this review studied more than one type of interaction, a total of 62 human-raptor interactions were found, from which 56% ($n = 35$) were categorized as positive and 44% ($n = 27$) as negative. Only 9 studies investigated positive and negative interactions at the same time. The most studied negative interaction or conflict was safety damage (11%; $n = 7$; Fig. 3A), while the most studied positive interaction or benefit was cultural service and pest control (each one 10%; $n = 16$; Fig. 3B).

Of the studies assessing positive interactions ($n = 28$), 79% ($n = 22$) confirmed their occurrence, while the remaining 21% ($n = 6$) found no evidence. In the case of studies examining negative interactions ($n = 26$), 77% ($n = 20$) verified the existence of conflicts, whereas the other 23% ($n = 6$) did not. Among the studies that confirmed the presence of negative conflicts, only six proposed management strategies to address or mitigate them.

All raptors orders had a greater number of published studies on negative interaction than on positive interaction (Fig. 4), but they stand out in different categories. For example, Strigiformes had the most studies on property damage and pest control (Fig. 4D). Accipitriformes were most studied as disease vectors and carrion removal (Fig. 4C) and were the only order studied with regards threats to human safety. The latter were only absent in pest control studies (Fig. 4C). Cathartiformes studies focused solely on disease spread and property damage (Fig. 4A). Finally, Falconiformes did not stand out in any category and were absent in studies of property damage, safety and carrion removal (Fig. 4B). Additional data of interactions discriminated by species are given in Supplementary Materials, Table S1.

## Discussion

Discussion section is structured as follows: First, we provide a brief overview of the current state of knowledge regarding conflicts and services of raptors in urban environments, including a discussion on geographic and taxonomic biases. We then divide the discussion into several sections. The first two sections, 'Human-Scavenger Interactions' and 'Human-Predator Interactions,' cover the generalities evidenced by the services and conflicts provided by each order of raptors. Following this, the discussion continues with the interactions defined in Table 1. To conclude, the reader will find a discussion on the management measures used or recommended in the studies.

Our global analysis revealed that raptor groups interacted differently with humans in urban environments, with certain orders dominating in specific conflicts and services. Our review also showed that raptors are underrepresented in studies on wildlife services and conflicts in urban environments, as other studies have shown (Soulsbury and White 2015; Nyhus 2016; Basak et al. 2023). The majority of species involved in services or conflicts are not classified as conservation concern, indicating an absence of study bias towards endangered species. This is unsurprising, as the traits that allow raptors to thrive in urban environments (see below in the "Human-Scavenger Interactions" section) also make them less vulnerable. Additionally, these non-threatened species are more common in cities, leading to more frequent interactions with people (Gaston 2010).

Robust geographic comparisons remain challenging due to the limited number of countries with more than three publications. Nevertheless, we conducted an exploratory analysis at the continental level, revealing a clear pattern: North America stands out for negative interactions, whereas South America and Oceania are more prominent for positive interactions. It is not surprising that North America and Oceania highlighted, as birds are frequently investigated in urban ecology studies in these regions (Magle et al. 2012). In contrast, given the increasing human-wildlife conflicts

**Table 2** List of species involved in human-raptor interactions in urban environments, detailing their respective orders and families, the number of studies reported and the global conservation status for each species. For the scientific names, we decided to use the same ones that were used in the reviewed studies. In bold, species with a global conservation status of concern. LC: last concern; NT: Near threatened; VU: vulnerable; EN: endangered; CR: critically endangered; NE: not evaluated

| Orders | Families | Species | No. studies | Conservation status |
|---|---|---|---|---|
| Cathartiformes | Cathartidae | *Cathartes aura* | 1 | LC |
| | | *Coragyps atratus* | 1 | LC |
| Accipitriformes | Accipitridae | *Accipiter cooperii* | 1 | LC |
| | | *Accipiter gentilis* | 1 | LC |
| | | *Accipiter nisus* | 1 | LC |
| | | *Accipiter virgatus* | 1 | LC |
| | | *Aegypius monachus* | 2 | **NT** |
| | | *Aquila chrysaetos* | 3 | LC |
| | | *Aquila fasciata* | 1 | LC |
| | | *Buteo fascinate* | 2 | LC |
| | | *Buteo jamaicensis* | 2 | LC |
| | | *Circaetus gallicus* | 1 | LC |
| | | *Circus aeruginosus* | 1 | LC |
| | | *Circus cyaneus* | 1 | LC |
| | | *Circus pygargus* | 1 | LC |
| | | *Geranoaetus polyosoma* | 1 | LC |
| | | *Gypaetus barbatus* | 2 | **NT** |
| | | *Gyps africanus* | 1 | **CR** |
| | | *Gyps fulvus* | 2 | LC |
| | | *Haliaeetus albicilla* | 1 | LC |
| | | *Haliaeetus leucocephalus* | 1 | LC |
| | | *Haliaeetus leucogaster* | 3 | LC |
| | | *Haliastur indus* | 3 | LC |
| | | *Haliastur sphenurus* | 3 | LC |
| | | *Hieraaetus pennatus* | 1 | LC |
| | | *Ictinia mississippiensis* | 2 | LC |
| | | *Milvus migrans* | 4 | LC |
| | | *Milvus malvas* | 2 | LC |
| | | *Necrosyrtes monachus* | 2 | **CR** |
| | | *Neophron percnopterus* | 2 | **EN** |
| | | *Nisaetus nipalensis* | 1 | **NT** |
| | | *Parabuteo unicinctus* | 2 | LC |
| | | *Pernis apivorus* | 1 | LC |
| | | *Stephanoaetus coronatus* | 2 | **NT** |
| | Pandionidae | *Pandion haliaetus* | 3 | LC |

**Table 2** (continued)

| Orders | Families | Species | No. studies | Conservation status |
|---|---|---|---|---|
| Strigiformes | Strigidae | *Aegolius acadicus* | 1 | LC |
| | | *Asio flammeus* | 3 | LC |
| | | *Asio otus* | 3 | LC |
| | | *Athene cunicularia* | 2 | LC |
| | | *Athene noctua* | 2 | LC |
| | | *Bubo nocaut* | 2 | LC |
| | | *Bubo scandiacus* | 1 | **VU** |
| | | *Bubo virginianus* | 2 | LC |
| | | *Glaucidium nana* | 2 | LC |
| | | *Megascops asio* | 1 | LC |
| | | *Megascops kennicottii* | 1 | LC |
| | | *Ninox scutulata* | 1 | LC |
| | | *Otus brucei* | 1 | LC |
| | | *Otus scops* | 2 | LC |
| | | *Psiloscops flammeolus* | 1 | LC |
| | | *Ptilopsis granti* | 1 | LC |
| | | *Strix aluco* | 3 | LC |
| | | *Strix mauritanica* | 1 | **NE** |
| | | *Strix nebulosa* | 1 | LC |
| | | *Strix rufipes* | 1 | LC |
| | | *Strix varia* | 1 | LC |
| | | *Surnia ulula* | 1 | LC |
| | Tytonidae | *Tyto alba* | 10 | LC |
| Falconiformes | Falconidae | *Caracara plancus* | 1 | LC |
| | | *Falco columbarius* | 1 | LC |
| | | *Falco peregrinus* | 3 | LC |
| | | *Falco subbuteo* | 1 | LC |
| | | *Falco tinnunculus* | 1 | LC |
| | | *Falco naumanni* | 2 | LC |
| | | *Milvago chimango* | 1 | LC |

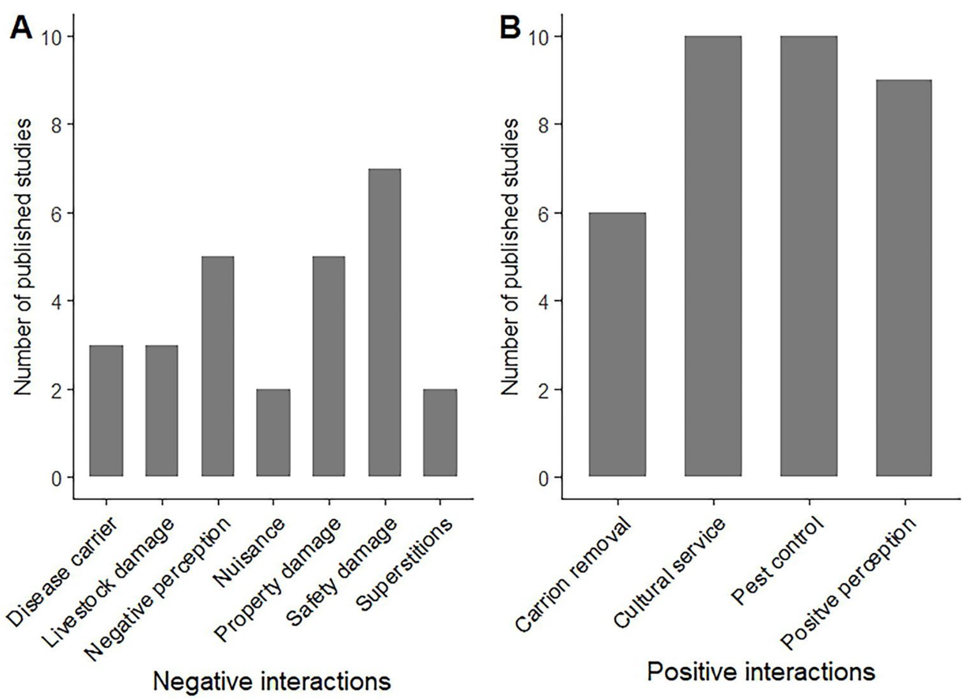


**Fig. 3** Number of total published studies per each negative (A) and positive (B) interactions

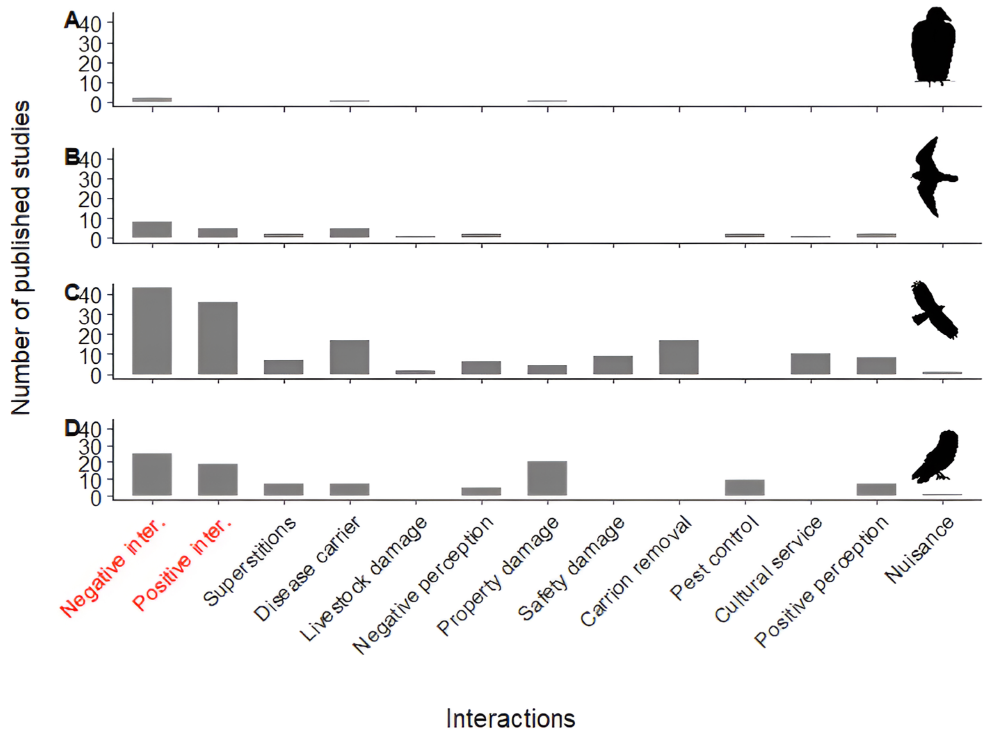


**Fig. 4** Number of studies published on negative and positive interactions (highlighted in red) and their respective subcategories for each group of raptors: Cathartiformes (A), Falconiformes (B), Accipitriformes (C) and Strigiformes (D)

caused by expanding human populations and urban areas in the countryside of Africa and Asia, it would be logical to expect a greater proportion of studies on negative interactions between humans and raptors in these continents. However, this result was not evident. Rather than indicating a lack of conflicts, this demonstrates, as previously shown by Magle et al. (2012), the concerning lack of urban ecology studies in these regions. These results reveal a geographic bias toward the northern hemisphere, consistent with observations in studies of urban ecology (Luederitz et al. 2015; Collins et al. 2021) and raptors (Kettel et al. 2018; Boal and Dykstra 2018; Canney et al. 2022). This bias also reflects social inequalities in science, as countries in the Global South face funding restrictions and limited scholarships for education or publication (Magle et al. 2012; McClure et al. 2022). Additionally, scientists from some developed countries are nowadays forced to flee due to war, political repression and the climate crisis (Machlis and Carrero-Martinez 2024). Certainly, international funding efforts for research, publication and education should be a priority in these areas. However, our selection of English-speaking studies may have influenced our results. In the future, as knowledge accumulates across countries, it would be interesting to investigate whether conflicts or services provide by raptors are influenced by specific country characteristics such as level of development, culture, religion or geographical location.

Across the studies included in our analysis, the predominant focus was on positive interactions rather than negative ones. However, upon closer examination within each raptor order, an opposing trend emerged: negative interactions outnumbered positive ones (see Fig. 4). This discrepancy can be attributed to the inclusion of diverse species in conflict studies, such as those associated with disease transmission or property damage, which increased the prevalence of negative interactions in orders like Accipitriformes and Strigiformes.

## Human-scavenger interactions

Among the raptors that consume carrion, including Accipitriformes, Cathartiformes, and Falconiformes, research on carrion removal services has primarily focused on facultative scavengers within the Accipitriformes (Table SM1). The relative lack of studies on vulture carrion removal in urban ecosystems compared to rural ones (DeVault et al. 2003; Grilli et al. 2019) may stem from their lower populations due to the high sensitivity of obligate scavengers to intense human impact, prevalent in the urban studies reviewed, although they benefit from moderate human impact as seen in some African countries (Buechley et al. 2018; Sebastián-González et al. 2019; McPherson et al. 2021a). These obligate scavengers, characterized by their large bodies and wingspans (DeVault et al. 2003), do not possess the traits typically associated with "archetypal urban raptors", such as being small and generalist, traits beneficial to thrive in urban environments (Cooper et al. 2021; Headland et al. 2023).

While this hypothesis may explain the scarcity of studies on carrion removal by vultures, it does not account for the similar lack of research on Falconiformes. It is particularly surprising given that this order includes the clade Caracaras, most of which are facultative scavengers, Some species have high local urban abundances (Ferguson-Lees and Christie 2001; Carrete et al. 2009; Morrison and Saggese 2024) and are known to exploit carcasses resulting from fauna-vehicle collisions (Biondi et al. 2005; Lambertucci et al. 2009) or livestock carcasses (Travaini et al. 2001; Autilio et al. 2019) (e.g. *Milvago chimango*, *Caracara plancus*, *Phalcoboenus australis*). Like Cathartiformes, Caracaras are primarily found in South America, which suggests that the geographic bias towards the Northern Hemisphere in this review could be contributing to the underrepresentation of carrion removal studies in these orders (Morrison and Saggese 2024). The high level of study on Accipitriformes in this service, as well as in other interactions throughout our review, may be attributed not only to biological or ecological factors but also to their cosmopolitan distribution and abundance as the most prevalent order among raptors (Winkler et al. 2020a). Clearly, future research is needed to assess the ability of both obligate and facultative scavengers to provide ecosystem services in urban environments and to determine their contribution to human communities.

## Human-predators interactions

Pest control facilitated by raptors stems from their foraging behavior reducing the need for costly management practices (e.g. pesticide) (Wenny et al. 2011). In our review of urban environments, Strigiformes emerge prominently in pest control studies, an expected outcome given their primarily carnivorous diet focused on small rodents (Winkler et al. 2020b, c). This role is well-established in agroecosystems (Sekercioglu et al. 2016; Mariyappan et al. 2023) and aligns with findings from Luna et al. (2021), which highlight that the most commonly observed carnivores in urban areas are those with nocturnal activity, coinciding with periods of reduced human activity (but see Gaston 2019 for an exception). This could explain the prevalence of studies focused on Strigiformes. However, there is a notable disparity when it comes to Accipitriformes, which, despite being among the most studied orders of urban predators alongside Carnivores (Luna et al. 2021), have seldom been researched for their role in pest control. This gap suggests that dietary studies of Accipitriformes in urban settings may not have explicitly targeted or tested their pest control capabilities, leaving a significant void in our understanding of their contribution to ecosystem services in these environments. A similar oversight exists for Falconiformes, even though they include urban-adapted species such as the Peregrine Falcon (Mak et al. 2021), which specializes in hunting birds. Despite this adaptation, only a limited number of studies explore their role in pest control. This indicates that natural pest control is presumed for these groups, but it has not been thoroughly studied. Lastly, it is unsurprising that there are no pest control studies involving Old World vultures (Accipitriformes) and New World vultures (Cathartiformes) given their specialized carrion-based diet (Winkler et al. 2020a, d).

## Positive interactions

### Carrion removal

Despite the positive impact that scavengers have on the environment, it is a topic that has been studied relatively little on a global scale (DeVault et al. 2003), particularly in urban environments (Luna et al. 2021). Our review underscores this information gap, as carrion removal is the least studied ecosystem service among all. However, align with global studies in scavenger communities (Sebastián-González et al. 2019), a pattern became evident during our review: carrion removal by raptors tends to decrease in urban areas compared to rural or pristine environments. This pattern may initially be observed because, with one exception, the studies were conducted in developed countries where waste management would be more effective (Mmereki et al. 2016; World Bank 2018). As a result, less carrion is available in these urban areas, limiting the activity of scavengers (Luna et al. 2021). In contrast, the only study that reported efficient carrion removal was conducted in a developing country, where such management practices may be less stringent (see below). Additionally, at the local level, the introduction of exotic species (Welti et al. 2020), infrastructure development and human presence (Huijbers et al. 2013, 2015; Thomson et al. 2016; Shizukuda and Saito 2023) were identified as the main factors affecting the regulatory service provided by raptors. The most alarming results were observed in Australia, where, across a gradient of urbanization, the ecosystem function of carrion removal by raptors was lost, and no other group replaced them in their absence (Huijbers et al. 2013, 2015; Thomson et al. 2016). An efficient case of carrion removal was observed in Yemen, where a high population of the Egyptian vulture (*Neophron percnopterus*) is supported due to the food sources, and as a consequence, they clean up 22% of the total putrescible waste matter in villages and rural areas (Gangoso et al.

2013). Considering that Egyptian vultures are globally listed as threatened (BirdLife International 2021), these findings underscore the importance of urban areas as potential conservation zones (McKinney 2002; Ives et al. 2016; Luna et al. 2021; McPherson et al. 2021a; Boakes et al. 2023). Not only do urban areas generate significant waste, but so do sites where animals are slaughtered for human consumption. This waste serves as a food subsidy for endangered species such as vultures (Buechley et al. 2022) or Black Kites (*M. migrans*) during their migration (Kumar 2023). Despite the critical role of human waste in supporting endangered or migratory scavengers, its presence undoubtedly enters in conflict with goals related to human health and urban development. Therefore, efforts aimed at managing and preventing zoonotic diseases in these areas will inevitably impact ecological functions (Plaza and Lambertucci 2017). 'Vulture restaurants' (i.e. safe feeding zones in areas inaccessible to humans) (Gilbert et al. 2007) could serve as a conservation strategy that simultaneously supports biodiversity conservation and protects human health (Adams et al. 2004).

As the decline of scavenger populations can increase human exposure to decomposing carcasses, raising the risk of pests and the spread of infectious diseases, further research is essential to understand the factors that influence the efficiency of this service and to develop effective management strategies, particularly for urban ecosystems (DeVault et al. 2016; Markandya et al. 2008; Buechley and Şekercioğlu 2016).

### Pest control

While studies on pest control by birds of prey are typically conducted in agroecosystems (Sekercioglu et al. 2016; Mariyappan et al. 2023), this review reveals a diverse range of pest control activities performed by raptors in urban environments. The most frequently reported is the control of rodents (Saufi et al. 2020; Cherkaoui et al. 2021), particularly those acting as reservoirs for and transmitters of the hantavirus (Magrini and Facure 2008; Teta et al. 2012; Godoy-Guinao et al. 2017). Additionally, control of invasive alien species (Mori et al. 2020), conflictive prairie dogs (*Cynomys ludovicianus*) (Witmer et al. 2008), pigeons (Columbiformes) (Schneider et al. 2023) and fruit pests were also documented (Kopij and Liven-Schulman 2012). One study aimed to test the hypothesis that the high abundance of pest species was attributed to a lower abundance of raptor species; however, it found no evidence to support this hypothesis (Sorace 2002). Although all of the studies reviewed are important and contribute to the knowledge of predatory species in urban environments (Luna et al. 2021), they often do not assess whether raptor foraging behavior effectively reduces pest populations or their harmful effects. Demonstrating that raptors consume pest species is insufficient to assume a decrease in damage caused by pests. For instance, raptors may not consume pests in sufficient quantities to significantly reduce damage, or pests may alter their foraging behavior rather than decline in population due to the presence of raptors (i.e. "landscape of fear" effect) (Whelan et al. 2008; Wenny et al. 2011; Bleicher 2017). Although methodologically challenging, detailed quantification of this regulatory service would be desirable to maximize the benefits of natural pest control by raptors in urban environments (Whelan et al. 2008; Wenny et al. 2011; Donázar et al. 2016).

### Cultural service

This review reveals that the cultural service of raptors was one of the most studied topics within urban environments, which may be due to the ease of collecting this type of information (i.e. through interviews). The studies reviewed demonstrate various ways in which birds of prey are integrated into urban culture, including religious ceremonies (Kumar et al. 2019; Gupta and Kumar 2021; Huang et al. 2021), recreational activities (Boal and Mannan 1999; Mayhew et al. 2016; Godoy-Guinao et al. 2017; White et al. 2018), literature about their hunting skills and myths (Molares and Gurovich 2018; Pitas 2021) and within language (Stara et al. 2016). Given the frequency of these positive interactions, and considering the daily interactions raptors have with people can generate a sense of belonging and cohesion among groups (Hunold 2017; Mak et al. 2021), researchers should undoubtedly incorporate social methodologies, such as ethnography, into their future studies. This approach would enable them to capture the cultural beliefs and values that shape interactions between humans and raptors (Stara et al. 2016; Bennett et al. 2017). Integrating social insights with ecological data will enable the development of more effective and context-specific management and conservation strategies (Mascia et al. 2003).

## Negative interactions

### Safety damage

Aggressive behavior, like physical attacks or other aggressive interactions or displays, is one of the most direct impacts that wildlife can have on humans (Soulsbury and White 2015). Within urban environments, our understanding of wildlife aggressiveness is limited. This may be because wildlife attacks are not frequently documented in scientific studies, although they do appear in the media

(Bhatia et al. 2013; Hathaway et al. 2017). Additionally, the scarcity of information could be attributed to the absence of large predators in urban areas (Soulsbury and White 2015). Nevertheless, there is a growing concern in this topic in urban raptors, as safety damage was the most extensively studied conflict in our review. In this sense, several behavioral shifts observed between urban and rural or natural counterparts have been attributed to three independent but not necessarily exclusive mechanisms: local evolution by divergent natural selection, phenotypic plasticity, and differential colonization process (Sol et al. 2013). Regardless of the specific mechanisms, animals in urbanized environments tend to exhibit increased aggression compared to their counterparts in rural or natural areas (Miranda 2017). As seen in mammals (McCullough 1982; Thompson et al. 2003) and highlighted in some studies in our review (McPherson et al. 2016; Kumar et al. 2018b, 2019), aggression sometimes is linked with intentional and unintentional human feeding of the predators, resulting in consequent loss of fear of humans.

Although the majority of studies were conducted during the reproductive season, a period typically associated with higher levels of aggressiveness (Montgomerie and Weatherhead 1988; Redondo 1989), these investigations predominantly reported low levels of aggressiveness with varied underlying causes. For instance, in India, aggressiveness of Black Kites was low and mostly occurred in areas with poor garbage disposal and, more importantly, where religious rituals involving feeding the kites were common (Kumar et al. 2018b, 2019). In contrast, in Japan, aggressive behavior of Black Kites was common and seems to be influenced by the landscape composition rather than human activities. In this sense, areas with fewer viable habitats for nesting and foraging witness a higher occurrence of aggressive behavior in Black Kites (Galbreath et al. 2014). Urban Mississippi Kites (*Ictinia mississippiensis*) exhibit lower levels of aggressive responses compared to their non-urban counterparts in the United States, likely because they have become accustomed to human presence (Skipper and Boal 2019; Boal et al. 2022). In this case, these negative results can contribute to carrying out management programs based on empirical facts to counteract the misaligned perceptions that exist about the aggression of this raptor (Dickman 2010; Boal et al. 2022). Attacks by the Crowned Eagle on pets were low (less than 1% of its diet) (McPherson et al. 2016) but enough to create negative human perception that may jeopardize the conservation of this raptor (McPherson et al. 2021b).

More research is necessary to rigorously understand the factors underlying and promoting the aggressive behaviors of raptors in urban environments. However, it cannot be overlooked that human behavior towards raptors might be a contributing factor to their increased aggressiveness. Therefore, it is essential to consider not only management actions targeting the wildlife involved but also how human behaviors contribute to the likelihood of conflicts (e.g., habituating raptors through supplementary feeding) (Nyhus 2016; Lambertucci et al. 2021). By doing so, accurate actions can be implemented that modify human behavior, favoring coexistence between humans and raptors (Mascia et al. 2003).

## Property damage

Basak et al. (2023) found that property damage by urban wildlife was the most common conflict. However, in our review, though well-documented, it ranks below studies on safety damage and was on par with negative perception. The documented damage primarily resulted from collisions with aircraft, with all incidents occurring in the United States. The reviewed studies involved owls (Linnell and Washburn 2018), eagles (Washburn et al. 2015), vultures (Washburn et al. 2013, 2014) and osprey (Washburn 2014). Overall, it was observed that most collisions occur inside or near airports, particularly during takeoff or landing. Another common finding is the significant increase in collisions over time for all groups of raptors studied, which researchers attribute to the rise in populations and an increase in voluntary reporting of collisions. This was the only conflict where economic costs were calculated, which ranged from $US 15,131 to $US 425,945, depending on the species involved.

Certainly, our review highlights a geographic bias and specific focus on property damage, as no other types of damage were reported, such as damage to buildings or physical structures due to nest construction, or damage to ornamental gardens (Peterson et al. 2010). More research is needed on the topic to determine if raptor cause other types of the damage to urban infrastructure.

## Livestock damage

Studies on livestock damage in urban areas were limited, as this is not a common activity carried out in cities. However, studies have documented instances of raptors preying on commercially used swifts (Dhamorikar et al. 2020), livestock (McPherson et al. 2016) and domestic species (Schneider et al. 2023). In all cases, the predation pressure was low and appears to have a negligible impact on economic activities. Given these results, it does not seem that damage to livestock is a conflict in which urban raptors are protagonists.

Nevertheless, potential opportunities for this type of conflict may become more frequent as backyard farming expands globally (Pollock et al. 2012; Mok et al. 2014). Considering that urban agriculture and raising chickens can enhance food security and social well-being, particularly in developing countries (Rajkumar et al. 2021), it is desirable to raise awareness in society about methods to exclude predators, akin to practices traditionally employed in rural areas (University of New Hampshire 2019; Bosques 2023).

### Disease carrier

Zoonotic diseases can increase with urbanization, especially in growing cities. The high density of humans, pets and wildlife in urban areas creates conditions that facilitate the spread of diseases through increased contacts between species (Ellwanger et al. 2022). In addition to being a threat to human health, diseases can also incur significant economic costs associated with preventive measures and health treatments for both humans and wildlife (Soulsbury and White 2015). Despite this, we found only a few studies that evaluated this conflict in urban raptors. Most studies highlighted the prevalence of bacteria posing health risks to humans, such as *Salmonella* spp. in American black vultures in Argentina (Plaza et al. 2019) and *Escherichia coli* in free-living raptors in Spain (Vidal et al. 2017). While these results underscore the potential of the studied raptors as reservoirs of pathogens affecting domestic animals and human health, the capacity for dispersal or transmission was not addressed. Opposite, one case study revealed a bacterial cellulitis infection caused by injuries inflicted by the claws of a Harris's hawk (*Parabuteo unicinctus*) (Khan et al. 2011), but no follow-up studies were conducted to evaluate the prevalence of this condition in this raptor's population.

These results suggest that little is known about the zoonotic diseases of urban raptors, specifically those caused by viruses such as Highly Pathogenic Avian Influenza (HPAI) or West Nile virus. Monitoring wild populations would be beneficial to fill these information gaps and to have early warnings of possible pathogens that could harm human health (Gray et al. 2023) and raptor populations (Pearce-Higgins et al. 2023).

### Nuisance

Only two studies highlighted nuisance of raptors in urban environments. In one of them, the Hooded vulture is considered a nuisance to the citizens of Ghana due to the theft of food and defecation when they invade homes (Campbell 2009). In the other study, homeowners removed nests from Barn Owls because they were bothered by the calls they made during the night (Pande et al. 2005). Although it has not been the conflict for which urban raptors stood out, urban wildlife is usually considered a nuisance (Soulsbury and White 2015). Indeed, crows, parrots and gulls have also demonstrated similar disruptive behaviors in urban settings (Belant 1997; Menchetti and Mori 2014; Campbell 2019; Benmazouz et al. 2021). Several management strategies have been implemented to address these issues. Among the simplest, most non-lethal and effective are modifications to nesting areas and reductions in foraging opportunities (e.g., at garbage dumps) (Belant 1997; Campbell 2019; Benmazouz et al. 2021). They could easily be implemented if the substrate to be used for nesting and the trophic resources consumed by the nuisance raptor species are known (see Mak et al. 2021). However, it is also crucial to consider the cognitive capacities of these birds, such as neophobia, innovation and several forms of learning, since these traits could enable them to flexibly circumvent non-lethal control measures (Barrett et al. 2019; Biondi 2022).

### Superstitions

Symbolic beliefs, such as myths, narratives and superstitions, often shape the way animals are socially perceived and could influence human attitudes toward them (Horgan et al. 2021). While there are superstitions about raptors in many aboriginal and rural communities, there is limited research on this matter in urban areas. In our review, we could only find two studies, both from South America, that identify superstitions. For instance, in Argentina, people perceive owls as diabolic creatures, mainly due to their anthropomorphic face, broad movement of the neck (about 270°), nocturnal habits, and diet based on rodents and amphibians (Molares and Gurovich 2018). Similarly, in Chile, superstitions associated birds of prey with bad ill-omen or evil (Muñoz-Pedreros et al. 2018).

Raptors have long been integral to mythical narratives and religious cultures (Macdonald 2006; MaMing et al. 2016; Sax 2021; Soni 2022,), influencing the superstitions prevalent among aboriginal and rural communities (Enriquez 2017). Notably, in urban areas like Delhi, India, religious rituals have been observed to influence Black Kites habitat selection (Kumar et al. 2018a). This raises both interesting and necessary questions about whether religious factors similarly contribute to the creation of superstitions in urban settings. Further research is essential to determine if superstitions that originate in rural areas, towns, or Aboriginal communities continue to persist in urban environments and to assess their potential role in conflicts between humans and raptors.

### Positive and negative perception

Perceptions could be defined as "the way an individual observes, understands, interprets, and evaluates a referent object, action, experience, individual, policy, or outcome" (Bennett 2016; p. 585). Thus, understanding people's perceptions about wildlife can assist in developing conservation and management plans, implementing environmental education programs to improve their public image and facilitating appropriate urban planning to conserve the ecosystem services they provide (Martínez-Abrain et al. 2008; Basak et al. 2022). People's perceptions of predators influence how they will behave towards them (Marchini and Macdonald 2018); therefore, it is important to document these responses. For instance, in Delhi, a megacity in India, the local populace shows remarkable tolerance towards the aggressive behavior of Black Kites due to their perceived benefits, including waste removal and their role in religious rituals (Kumar et al. 2019).

A clear pattern evident in previous studies (Kansky and Knight 2014; Puri et al. 2024; Zhao et al. 2024) also emerged in the studies we reviewed: citizens who had close contact with raptors generally developed positive attitudes towards them and showed a greater interest in their protection. Conversely, indifference and negative perceptions were more prevalent among individuals who did not recognize the raptor species or had not interacted with them. For example, in both the United States and Chile, people's perceptions of Red-tailed Hawks and Barn Owls, respectively, improved with increased interaction with the birds in their nests (Godoy-Guinao et al. 2017; White et al. 2018). Another example occurs with vultures of the genus *Gyps* spp. and *Neophron* spp., where people over 35 years of age recognized cultural and carrion removal services from these birds because they had more experiences living with them than the younger ones (Gupta and Kumar 2021). An exception was found in Chile, where urban residents demonstrated low knowledge and identification of raptor species; however, despite this, they had a greater desire to protect birds of prey due to the pest control service they provide, compared to rural citizens (Muñoz-Pedreros et al. 2018). This aligns with previous studies that document extinction of experience, less persecution and greater respect for birds of prey in cities (Miller 2005; Boal and Dykstra 2018).

Environmental education and recreational activities that bring people into contact with raptors can improve people's perception. In Argentina, students exhibited a positive change in attitude towards owls after a school laboratory experience dissecting owl pellets, where they learned about the crucial role these birds play in controlling rodents that transmit hantavirus (Molares and Gurovich 2018).

Some studies have revealed that people may hold both positive and negative perceptions towards birds of prey, and these perceptions may vary by geographic location. For example, Hooded vultures (*Necrosyrtes monachus*) are recognized for their carrion and waste removal services in Guinea Bissau and Ghana. However, there are concerns in Guinea Bissau that they might transmit diseases (Henriques et al. 2018), while in Ghana, people are worried about the theft of good food and nuisance behavior (Campbell 2009). Another example is the reintroduction of the white-tailed sea eagle (*Haliaeetus albicilla*), where the majority of people, especially in urban areas, supported the reintroduction due to the species' utilitarian values (e.g. economic gains from ecotourism), while farmers were concerned about potential damage to their livestock (Mayhew et al. 2016). Despite several studies investigating people's perception of urban raptors through interviews, such studies did not constitute the majority in this review. Moreover, only a few of them combined this social methodology with the evaluation of conflicts or services through experiments or observations. Given that cities are socio-ecological systems (Liu et al. 2007; Francis and Chadwick 2013), it is crucial to incorporate the study of human dimensions when examining urban species (Horgan et al. 2021; Basak et al. 2023). Attempting to identify and manage a conflict or maximize a service requires researchers to investigate people's opinions about the raptors species and the interaction to be evaluated. This is because people may not perceive the service or conflict or may disagree with the measures taken, potentially impacting their effectiveness in the future (Basak et al. 2023). For example, species typically considered pests, such as pigeons or parakeets, may be viewed affectionately by some members of the public due to their frequent presence and interactions with people (Francis and Chadwick 2013; Crowley et al. 2019). Combined with people's extinction of experience with nature (Miller 2005), raptors that prey on these species might be perceived negatively (Mak et al. 2021), leading to a devaluation of their pest control services. Recognizing and addressing these dualistic perspectives is essential for providing a comprehensive understanding of public attitudes towards raptors. This knowledge is crucial for designing educational programs and conservation strategies that not only foster public support but also enhance the effectiveness of interventions, benefiting both human communities and raptor populations (Burby 2003; Coz and Young 2020; Mak et al. 2021; Jones 2024).

## Management measures

Although many studies demonstrated the existence of human-raptor conflict, few suggested management measures to reduce them. A full description of all the measures used or proposed to manage conflict and increase services is beyond the scope of this review. However, one widely suggested measure is environmental education. Since many people reside in or near to urban areas, there are ample opportunities to foster an ecologically informed public that appreciates nature and values its conservation (McKinney 2002).

Environmental education programs and persuasive communication about urban raptors could inform people about the ecosystem services and benefits they offer, such as pest control, and provide methods to avoid conflicts with them (Bruskotter and Wilson 2014). Additionally, these programs could encourage greater tolerance towards minor conflicts like nuisances or superstitions, especially when the perceived risks do not align with reality (Pande et al. 2005; Dickman 2010; Barrett et al. 2019; Lambertucci et al. 2021). They can also educate the public on when certain actions, such as providing supplementary food, might have both positive effects (providing a close nature experience or a conservation action for endangered raptors, e.g., "food restaurants" for vultures) and/or negative consequences (potentially habituating raptors and increasing aggression). This knowledge can empower people to take actions that benefit both humans and birds of prey (Bruskotter and Wilson 2014; Arnulphi et al. 2017).

By applying these recommendations and considering the various human dimensions that influence tolerance towards raptors and wildlife in general, education programs could promote coexistence between humans and raptors (Kansky et al. 2016, 2021; Kansky and Kidd 2024).

Despite the effective results evidenced in this review, for environmental education to be an efficient strategy to promote coexistence between humans and raptors, it is important to highlight that researchers must be open to what people can understand and relate to in nature, even if it differs from the scientific point of view. Therefore, they must avoid imposing their "scientific vision" on the public (see examples of these situations in rewilding projects (Deary and Warren 2017; Pettersson et al. 2023). Furthermore, when planning education programs, it is crucial to consider the heterogeneity of tolerance and perceptions based on demographic factors to make education and communication strategies appropriately for the target audience (Puri et al. 2024). Finally, programs should go beyond merely providing information and should also facilitate encounters with wildlife. Promoting activities like birdwatching for urban raptors in parks allows people to learn and appreciate these interactions firsthand (Ballantyne et al. 2007; Bruskotter and Wilson 2014; Puri et al. 2024).

# Conclusion

Based on our review, raptors play a crucial role in urban environments, either by providing ecosystem services or by causing conflicts with humans. However, much remains to be explored in this field, as only three types of interactions (pest control, cultural services, and safety damage) and two orders (Accipitriformes and Strigiformes) have been studied extensively. Moreover, our review underscores the lack of transdisciplinary studies that integrate social and ecological approaches. Given that urban environments function as socio-ecological systems, we noted that human dimensions significantly influence the occurrence and magnitude of certain interactions, including safety, superstition, cultural services and both positive and negative perceptions. Consequently, it is essential to understand not only the ecological dynamics of these interactions but also to integrate social perspectives (Basak et al. 2022). This approach is vital not only for uncovering the underlying causes of specific conflicts but also for understanding people's perceptions of raptors. We support the call for a holistic research approach, as previously advocated in raptor conservation (Canney et al. 2022; Carucci et al. 2022), to minimize human-wildlife conflicts in urban settings (Dickman 2010; Basak et al. 2022, 2023) and more broadly within the field of conservation (Mascia et al. 2003; Bennett 2016; Bennett et al. 2017). Additionally, implementing experimental alongside observational studies would be beneficial to thoroughly evaluate ecosystem functions and quantify the extent of services and conflicts associated with raptors in urban environments (Whelan et al. 2008). Adopting these approaches will likely enhance the coexistence between humans and raptors in urban landscapes.

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**Data availability** The data presented in this study is available in Table SM1 of the supplementary material.

## Declarations

**Competing interests** The authors declare no competing interests.

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