Chapter 8

Costs and Benefits of Urban Living in Raptors

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Introduction

Increasing human populations have accelerated urbanization and altered natural habitats. This process began in the eighteenth century with the industrial revolution when workers began moving to cities leaving agricultural jobs for jobs in manufacturing. Global growth in human populations was accompanied by growth of cities, which has increased the demand of goods and services provided by the exploitation of natural ecosystems. Rapid worldwide urbanization has led to a rampant loss of natural habitats and habitat fragmentation, which alarmed to ecologists and conservationists that have focused their researches in last years to understand the response of wildlife to these new scenes. For birds, the number of published studies on urban effects has increased steadily (Marzluff et al. 2001; Marzluff 2017). However, raptors have been poorly studied during much years, mainly due to several limitations imposed by their natural history (i.e., low densities, large home ranges, variable reproductive behaviors, and inaccessible breeding sites) (Donázar et al. 2016) and the high costs necessary for these studies. Nowadays, research of raptors in urbanized habitats has increased considerably. We will focus on a variety of these aspects.

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Urban Living in Birds

Birds are probably the most evident and conspicuous wild vertebrates among those living in and adapting to urban environments. Urban parks around the world, for example, hold at least one but usually many bird species, even in those cities most densely populated or located in regions with extreme weather conditions. Birds are also found in a variety of less suitable and more stressful sites inside cities and many of these species breed, forage, and roost on buildings, noisy streets, and avenues.

The study of such avian tolerance to urban environments probably derived from some simple and straightforward questions: How do these birds live and survive in habitats quite different from natural environments? Why are some species found in cities while others are not? What are the consequences and/or profits for these urban-living individuals? Urban living in birds probably started progressively when birds and human began sharing the same physical space, birds because natural habitats were invaded by humans and humans because they chose habitats in which birds lived. This situation was forced by human development and driven to a nonrandom distribution of bird assembles in distinctive ecological habitats that reflect the impacts of urban sprawl on native species. Ecologists studying bird ecology and behavior in urban environments frequently employ the characterization of bird assemblages proposed by Blair (1996), in which three groups are described with regard to their adaptability to urban environments: avoiders, adapters, and exploiters.

Urban avoiders comprise those species particularly sensitive to human-induced changes and which reach their highest densities in less-disturbed natural habitats. These species are the first to disappear in the proximity of humans and the spread of urban development. Urban avoiders include species adapted to live in the interior of old and large forests, migrants, and nesting birds that may be very sensitive to human presence.

Urban adapters include those species able to exploit some additional resources present in moderate levels of urbanized habitats such as suburbs. These species are usually generalist "edge species" that exploit different habitat types and food sources (including human-subsidized foods such as cultivated plants, garbage, and insects attracted to artificial lights), ornamental plantations (for shelter and nesting structure), and open areas. Urban adapters include mostly omnivores and ground foragers, seedeaters, and aerial sweepers such as swifts.

Urban exploiters are species having the skills to exploit urbanized habitats that seem to be very dependent on resources provided by human presence, reaching their highest densities in these developed sites. Urban exploiters experience reduced densities of predators and abundant food resources. These species are usually more common and abundant in cities than in natural habitats. In several cases, urban exploiters are represented by invasive non-native species. In birds, urban exploiters are species originally adapted to cliff and rocky areas and therefore preadapted to exploit shelter and nesting opportunities provided by buildings and other human structures.

Raptors in Urbanized Habitats

The response of raptors to urbanization varies much and depends on species-specific traits, such as home-range requirements, food habits, demography, and behavior, and also on the degree of habitat transformation itself. In general, negative effects of urbanization on the abundance, richness, and diversity of raptor species should be expected (Ferguson 2004; Carrete et al. 2009).

For those species in which urbanization depicts some critical landscape threshold, some minimum degree of urbanization could limit the presence of species with specific habitat requirements that urban landscapes do not provide. Examples include eagles, some large hawks, and falcons (Berry et al. 1998) which have large home-range requirements and could be considered as "urban avoiders" (but see, e.g., McPherson et al. 2016; Kauffman et al. 2004).

There are, however, small- to medium-sized raptors, such as hawks, kestrels, and owls that can be found in urbanized landscapes (Berry et al. 1998; Rullman and Marzluff 2014), and although some species may be more abundant in natural or rural areas, they can reach high abundances in areas with moderate levels of urbanization (Bellocq et al. 2008; Carrete et al. 2009). For these species, preservation of patches of native grasslands or woodlands can enhance the probability of occupation of these areas (Hogg and Nilon 2015). These species which can be considered "urban adapters" can be found usually in areas peripheral to urbanized locations or in suburban environments where their home ranges may extend beyond urban boundaries in order to meet the ecological requirements that urban areas cannot provide.

Breeding in Urban Environments

Since many species of raptors do breed in urbanized habitats, urban areas may not be the suboptimal habitats that they are often assumed to be. Species such as peregrine falcon (*Falco peregrinus*), Cooper's hawk (*Accipiter cooperii*), lesser kestrel (*Falco naumanni*), Eurasian kestrel (*Falco tinnunculus*), Eurasian sparrowhawk (*Accipiter nisus*), and burrowing owl (*Athene cunicularia*), among others, are often seen breeding in urbanized landscapes (Table 8.1). In modern times, these habitats have been described to be free from persecution and, if these habitats or its surrounding area have an adequate food supply, may allow raptors to breed in these areas which might otherwise be considered unsuitable.

Reproductive output in urbanized habitats is highly variable (Chace and Walsh 2006). Burrowing owls, for example, have lower nesting success in natural habitats than they do in human-altered areas on the campus of a university in Las Cruces, New Mexico (Botelho and Arrowood 1996). Mississippi kites (*Ictinia mississippiensis*) also have higher productivity among urban pairs than rural pairs in North America (Parker 1996). Endangered lesser kestrels have larger clutch sizes

Table 8.1 Literature that addresses the variation in reproductive parameters of raptor birds in different gradients of urbanization

Species	Reproductive parameter	↑U, ↓RO	↑U, =RO	↑U, ↑RO	Reference
Bald eagle (*Haliaeetus leucocephalus*)	No differences in reproductive success between areas with different degrees of human activity, except eagles in areas with greater human activity produced more chicks and had larger broods than eagles of forests		X	X	Fraser et al. (1985)
	Number of young fledged per occupied nest site or from successful nests did not differ between suburban and rural nest sites		X		Millsap et al. (2004)
Barn owl (*Tyto alba*)	Unsuccessful nesting sites were associated with more improved grassland, suburban land, and wetlands than successful sites	X			Bond et al. (2005)
Black sparrowhawk (*Accipiter melanoleucus*)	No differences in brood size, reproductive success, and productivity in gradients of urbanization		X		Rose et al. (2017)
Burrowing owl (*Athene cunicularia*)	Human-altered pairs with more nestlings, fledglings, and young than pairs in natural areas			X	Botelho and Arrowood (1996)
	Higher reproductive rate in urban than in more rural areas and lower in areas of very high urban development	X when development is greater than 60%		X when development is less than 60%	Millsap and Bear (2000)
	Higher reproductive success, productivity, and brood size in urban than rural habitats			X	Rebolo-Ifrán et al. (2017)

(continued)

Table 8.1 (continued)

Species	Reproductive parameter	↑U, ↓RO	↑U, =RO	↑U, ↑RO	Reference
Chimango caracara (*Milvago chimango*)	Higher reproductive success and productivity in rural and natural than in suburban habitats	X			Solaro (2015)
Cooper's hawk (*Accipiter cooperii*)	Greater overall proportion of nests that failed in urban than in undeveloped or natural areas	X			Boal and Mannan (1999)
	Similar productivity in urban and rural habitats		X		Rosenfield et al. (1995)
Eastern screech owl (*Otus asio*)	Fledgling per breeding pair and percentage of successful nests increased with urbanization			X	Gehlbach (1996)
Eurasian kestrel (*Falco tinnunculus*)	Lower clutch size, number of hatched offspring, and number of fledged young in urban than in suburban sites	X			Sumasgutner (2013)
	Higher hatching rates and larger fledged brood sizes in vicinity of green backyards. Lower productivity in urban centers than in suburban areas	X			Sumasgutner et al. (2014a)
	Reproductive sites in inner city are associated with lower hatching rates and smaller fledged broods than suburban sites	X			Sumasgutner et al. (2014b)
	Similar reproductive success (clutch size, hatched young, and fledged young) in three areas of gradient of urbanization (city center, mixed zone, and outskirts)		X		Kübler et al. (2005)

(continued)

Table 8.1 (continued)

Species	Reproductive parameter	↑U, ↓RO	↑U, =RO	↑U, ↑RO	Reference
Lesser kestrel (*Falco naumanni*)	Clutch size and fledging success higher in rural than in urban colonies	X			Tella et al. (1996)
Mississippi kite (*Ictinia mississippiensis*)	Higher productivity in urban than in rural colonies			X	Parker (1996)
Red-shouldered hawk (*Buteo lineatus*)	Number of nestlings per active nest did not differ between suburban and rural areas		X		Dykstra et al. (2009)
Red-tailed hawk (*Buteo jamaicensis*)	Nests with high productivity were located in areas of roads and high-density urban land and nests with less productivity were in wetland land			X	Stout et al. (2006)
	Productivity did not differ among urban, suburban, and rural nest sites		X		Stout et al. (1998)

U urbanization, *RO* reproductive output, ↑ increase, ↓ decrease, = the parameter remains the same

and greater fledgling success in rural habitats than in urbanized habitats in Spain, even accounting for reduced food availability in cities and higher losses of nestlings due to starvation in urban colonies (Tella et al. 1996). Although the extent of urbanization surrounding black sparrowhawk (*Accipiter melanoleucus*) nests sites did not seem to have a strong influence on breeding performance, the seasonal declines in productivity differed according to levels of urbanization (i.e., highest productivity had been found in more urbanized habitats earlier in the season, but toward the end of season, breeding performance was better in less urbanized habitats) (Rose et al. 2017). A revision over the response, in reproductive terms, of raptor birds to gradients of urbanization is presented in Table 8.1.

Numerous factors can affect the reproductive success in urbanized landscapes. The way that raptors confront and exploit the resources or characteristics of these habitats will be reflected in their reproductive output. Studies of the breeding biology of raptors in urbanized habitats have cited and described the factors driving their breeding success as being nest site availability, food availability, proximity to green spaces, breeding density, and predation pressure.

Nest Site Availability

For those raptors that do not construct their own nests, the availability of suitable nest sites seems to be a limiting factor (Newton 1979), and in urban settings, buildings provide attractive breeding sites. Although historical centers of cities can offer numerous potential nest sites on buildings and raptors may be present in high densities, these factors do not necessarily mean high-quality habitat; therefore higher rates of nest failure, lower hatching rates, and smaller brood sizes at fledging can be expected for species nesting in urban centers (Sumasgutner et al. 2014a, b).

Diet, Food Abundance, and Prey Availability

Some raptors breeding along urban gradients change their prey preferences as a function of the degree of urbanization (Kübler et al. 2005). For Eurasian kestrels in Vienna, Austria, the diet of individuals breeding in urban centers was more diverse and generalist than the diet of their suburban and rural counterparts (Sumasgutner 2013). The abundance and availability of prey vary along urban gradients, in many cities around the world with many non-native prey species being very abundant in the center (e.g., domestic pigeons *Columba livia*, house sparrows *Passer domesticus*, or common starlings *Sturnus vulgaris* in American cities), and consequently more represented in the diet of individuals that breed in city centers (Haiman 2006; Cava et al. 2012; Sumasgutner et al. 2014a).

Proximity to Open Green Spaces, Parks, or Forest Remnant Inner Cities

Green spaces are very important in cities because these areas have high biodiversity and provide breeding sites to species, especially if these spaces have a high percentage of native plant species (McKinney 2002). These nodes do need to be connected by backyards or other green corridors to ensure dispersal and to serve as valuable foraging sites (Rudd et al. 2002). These habitats can affect the reproductive output, as was demonstrated by Sumasgutner et al. (2014a) who found that individuals breeding close to green backyards had earlier clutch dates, higher hatching rates, and larger fledged brood sizes.

Breeding Density

In social and colonial species, the distance to the nearest neighbor (nearest neighbor distance (NND)) is a measure that depicts the spatial distribution of nests and is widely used to evaluate birds' density (Newton 1998).

Several studies have shown that although individuals of the same species breed more densely (i.e., lower NNDs) in urban core, these sites are associated with higher nest failure, greater predation, increased nest desertion, lower hatching rates, smaller broods at fledging, and greater mortality by diseases (Boal and Mannan 1999; Sumasgutner et al. 2014b). For the social raptor chimango caracara (*Milvago chimango*), smaller NNDs in a suburban colony were associated with smaller clutch and brood sizes (Solaro and Sarasola 2015). In these cases, cities seem to act as ecological traps, habitats that appear favorable for some particular features (i.e., high nest sites availability) but are actually unsuitable or of lower quality (Schlaepfer et al. 2002).

Breeding density can be an important factor of protection from nest competitors too. Black sparrowhawk and Egyptian geese (*Alopochen aegyptiaca*) have recently expanded their South African ranges, and both species breed in urban and suburban habitats. A multiple nest building strategy has been an effective method used by black sparrowhawks to avoid negative interactions (i.e., nest usurpation) with Egyptian geese; thus breeding more densely was the used strategy to maintain productivity in this population of raptor species (Sumasgutner et al. 2016).

Predation Pressure

Human development can displace native predators in urbanized habitats. If prey species are less sensible to human perturbation than their predators, they may be favored by a "predation release" in these habitats (Muhly et al. 2011). For raptors, differential predation risk between urban and rural habitats can affect the breeding habitat selection. Although rural and natural habitats were much more extended, urban habitats were positively selected by burrowing owls in Argentina during the reproductive season due to very low richness and abundance of predators in these habitats, which can be reflected in the high reproductive outputs of urban populations (Rebolo-Ifrán et al. 2017). High productivity has been associated with low predation pressure in urban habitats for Mississippi kite and lesser kestrel too (Parker 1996; Tella et al. 1996). In this sense, cities have been suggested as key conservation hotspots to those species with threatened native habitats but that are able to live in high human-modified habitats (Rebolo-Ifrán et al. 2017).

Fear of Humans and Habitat Selection

Urbanization could be understood also as the process of a species entering urban habitats in which individuals exploit ecological and behavioral features that allow them to adapt to an urban existence. Among these behavioral features, raptors need to accommodate their fear of humans. For practical purposes, this behavioral trait can be quantified by the flight initiation distance (FID), which is the distance between an approaching threat (i.e., human) and a perched bird just as it takes flight (Blumstein 2006). Many studies of fear of humans have highlighted the differences in this behavior when comparing birds living in urban and rural habitats. In general, urban species are less fearful of humans than rural species (Møller 2010) and within species, individuals in urban populations have FIDs consistently lower than individuals in rural populations (Cooke 1980; Gliwicz et al. 1994; Møller 2008; Lin et al. 2012; Díaz et al. 2013).

In birds, inclusion of a species in urban habitats is usually the result of a complex selective process operating on the behavioral variability of populations. Originally, species with more variable FID are more successful in colonizing cities, and then over time, FIDs become reduced and more homogeneous among urban populations. We would expect that only species with a specific subset of behaviors (lower FIDs) are to be represented in urban populations (Møller 2010). Low FIDs in urban birds indicate a reduced perception of predation risk and allow closer approach to potential resources (Sol et al. 2011).

Studies of fear of humans shown by raptors are limited (Carrete and Tella 2010, 2011, 2013; Díaz et al. 2013; Rebolo-Ifrán et al. 2015; Carrete et al. 2016; Cavalli et al. 2016) and are aimed to clarify why and how some species are able to adapt to urbanized environments. In general, these authors have found that urban raptors have significantly shorter mean FIDs than what is found for rural populations in a variety of raptor species around the world.

Studies measuring FID in environments with different degrees of human disturbance have concluded that low mean FIDs in local population of more human disturbed habitats can be attributed to habituation process (Blumstein et al. 2003; Martínez-Abraín et al. 2008; Rodriguez-Prieto et al. 2009; Samia et al. 2015), but these studies have been criticized in that they focused on central tendency measures rather than on individual variation of FID (Carrete and Tella 2010; Lin et al. 2012). Repeatability of individual FID values in burrowing owls has been measured in short-term studies and throughout an adult's life span, and notable individual consistency in this trait has been found (Carrete and Tella 2010, 2013) suggesting that habituation is not occurring in this trait. Individual variability in FID measures and not the population mean value explains the uneven occupation of human-altered territories by individuals with different tolerances to human disturbance, i.e., precluding more frightened individual to colonize more humanized environments. This nonrandom habitat selection hypothesis would be supported by a pattern of more tolerant individuals ("tame" individuals) occupying more disturbed environments rather than by individuals becoming more habituated (Carrete and

Tella 2010, 2011, 2013). Selection acting on this behavioral trait can have important ecological and evolutionary consequences, i.e., if less fearful individuals are positively selected in disturbed environments (Carrete and Tella 2010), then these populations would result in more explorative and aggressive individuals (Evans et al. 2010). This process would change the dynamics among selected individuals and should be considered as an important but unappreciated ecological and evolutionary force (Carrete et al. 2016).

Cavalli et al. (2016) found that FID is significantly lower for urban burrowing owls than for rural owls and that urban individuals show more aggressiveness than rural individuals, indicating that urban environments would select for individuals that are less fearful and more aggressive toward potential predators than individuals in rural environments. Moreover, urban individuals would recognize different predators (human with a dog or human alone) and act appropriately with a differential aggressiveness level toward potential (human) or real (dog) predators, while rural individuals would perceive both human and dogs as real predators and react by flying away earlier (high FID) to avoid aggressive encounters (low aggressiveness) and non-necessary energetic costs.

Heritability of the behavioral trait "fear of humans" has been studied in burrowing owl in order to assess whether FID has a heritable component. Although in their study Carrete et al. (2016) have not found any statistical differences between rural and urban individuals, they have found a high heritability in FID compared with other antipredator behaviors. This is another reason to consider pressures of selection on this behavioral trait as an important evolutionary force in animal populations that are exposed to human disturbance (Fig. 8.1).

In rural or natural habitats, fear of human positively correlates with other behavioral traits as antipredatory and exploratory behaviors, i.e., individuals with larger FID when facing human shows longer latencies in approaching a predator and a new food item. However, in a context as urban habitats in which there is a low predation pressure, antipredatory behavior would be selected against, thus breaking or dismantling the correlation between FID and antipredatory behavior. In this sense, Carrete and Tella (2017) proposed that changes in selection pressures acting in urban areas can change the relation between behavioral traits, maintaining only those that are adaptive in these environments (e.g., FID exploration but not FID-antipredatory behavior).

Behavioral Flexibility

When an animal is exposed to a novel environment, behavioral flexibility can be an advantage to respond more rapidly to these changes. What is behavioral flexibility in urbanized environments? Behavioral flexibility implies learning, cognition, and rapid adjustment to new conditions, which allows animals to exploit a wide variety

Fig. 8.1 Burrowing owls and chimango caracaras are two common raptors usually found in urban and suburban areas in cities of southern South America. (**a**) Brood of burrowing owl in its nest sited few meters from a house. (**b**) Two chimango caracaras, an adult and a fledgling, drink water of an unusual water source, a pool of a house in an urbanized area. (Photo credit: (**a**) J. Hernán Sarasola, (**b**) Claudina Solaro)

Fig. 8.1 (continued)

of resources in different ecological contexts. Then, species that readily exploit a new food resource are preadapted for novel environments in contrast with more specialized species.

Behavioral flexibility has been hypothesized to be advantageous for surviving and reproducing in novel environments (Sol and Lefebvre 2000; Sol et al. 2002; Møller 2009). This flexibility has been associated with the relative size of the brain. Species with a large forebrain (relative to body mass) have behaviors that are more flexible and are more successful for establishing in novel environments. Large brains confer cognitive advantages that allow responses to novel conditions through enhancing their innovation propensity (Sol et al. 2005).

Sol et al. (2011) proposed that common mynas (*Acridotheres tristis*) construct novel behaviors to facilitate colonization of urban habitats in which man-made resources represent much of their diet and individuals need to innovate in order to be able to consume them. They showed that urban individuals had less aversion to approaching novel objects (neophobia), lower risk perception (lower FIDs), and greater exploration (measured as the physic exploration of an apparatus used for the experimental procedure) than rural individuals. These three traits drove urban individual to approach, explore, innovate, and consume the novel resource instead of avoiding it.

Studies on non-captive raptors over their behavioral flexibility in the form of neophobia, exploration, and learning have started in recent years. Beissinger and collaborators (1994) have studied diet specialization in snail kites (*Rostrhamus sociabilis*) in an experiment with wild free-flying birds and found that this species showed risk-averse foraging and neophobia toward eating non-habitual prey and thus maintained their strong specialization in feeding almost exclusively on *Pomacea* snails. This is an example of a species that, considering its specialized diet, would be unsuccessful in urbanized habitats.

In the last decade, six experimental works over behavioral flexibility have been developed in Argentina with wild individuals of the same species: the chimango caracara, a very common raptor in southern South America that lives and breeds in a wide variety of environments including urbanized habitats (Bellocq et al. 2008; Pedrana et al. 2008; Carrete et al. 2009; Solaro and Sarasola 2015, 2017). To clarify the characteristics that enable the ecological success of this species, researchers have hypothesized on neophobia, learning, exploration, and problem-solving capability of urbanized chimango caracaras but have not examined non-urban populations. Juvenile chimango caracaras have been found to have a remarkable ability to obtain food in novel situations and an ability for individual learning (Biondi et al. 2008). Age differentiation in exploration, neophobia, and problem-solving ability were found, which showed juveniles to have a higher explorative tendency, lower neophobia, and greater ability to innovate than adult individuals (Biondi et al. 2010a, 2013, 2015). Chimango caracaras are able to solve a food-related problem by observing the behavior of a conspecific, and this new behavior persists through several days, which shows an adaptive advantage considering the gregarious habits of this species (Biondi et al. 2010b). Guido et al. (2017) studied neophobia and reversal learning in chimango caracara and found that individuals were able to respond to a stimulus-reward association, but reverting to any previously learned association is a harder task. Urban chimango caracaras have been found to cope with novel features of their surroundings (Fig. 8.1). Although similar studies of individuals across a rural-urban gradient have not yet taken place, the studies cited above propose that generalist habits and low neophobia, high exploration, and learning can be critical features to discover and exploit new resource opportunities in modified habitats as developed land or cities.

Threats in Urban Landscapes

Urbanized habitats offer opportunity for those species that can successfully confront novel features and exploit new resources; however, these urban habitats also offer a variety of threats to urban birds that may affect their survival. Increased demands for resources and socioeconomic changes in the modern societies have driven the development of infrastructures for transportation and energy. These infrastructures have shifted mortality factors affecting raptors (Donázar et al. 2016). Current threats to urban birds include collisions with structures and vehicles, intoxication, diseases, and electrocution (Marra et al. 2004; Bradley and Altizer 2007; Hager 2009; Hager and Craig 2014; Cusa et al. 2015). In urbanized environments, birds have died more often from human-related causes than birds in rural environments.

In the United States and Canada, the primary sources of mortality for urban raptors were vehicle collisions (>60% of urban raptors), windows strikes, and electrocutions (Hager 2009). The proportion of raptor casualties from window collisions is similar for both urban and non-urban raptors, suggesting that urban raptors, mainly owls, are not especially vulnerable to this source of mortality. In any case, window collisions affect hawks and falcons more than other raptors (Hager 2009). Collisions have been a major source of mortality for post-fledgling urban raptors, a factor which should be considered in population studies undertaken to estimate survival, mortality, and migration flow.

The major causes of mortality for bald eagles (*Haliaeetus leucocephalus*) in suburban habitats of West Central Florida, USA, were electrocution, vehicle collisions, secondary poisoning from predator control efforts, and disease (Millsap et al. 2004). Poisoning in bald eagle may have been caused by eagles foraging on carcasses of euthanized pets in landfills, a problem resolved by requiring burial of poisoned carcasses. Chlamydial infection in suburban bald eagles has been caused apparently by their interaction with monk parakeets (*Myiopsitta monachus*) because eagle nests are frequently used also by monk parakeets. Monk parakeets have increased only in urban and suburban areas in Florida, and interactions between eagles and parakeets are stronger in suburban than in rural environments. Among urban nesting

Cooper's hawks in Arizona, 85% of nestlings tested positive for (and 79.9% of nestlings died due to) trichomoniasis, an avian disease caused by the parasitic protozoan *Trichomonas gallinae* (Boal et al. 1998; Boal and Mannan 1999). In Victoria, British Columbia, *T. gallinae* affected, but did not kill, three nestling Cooper's hawks (Rosenfield et al. 2002). It seems to be a lower prevalence of this parasite in the northern portions of this hawk's breeding range (Rosenfield et al. 2009). The spread of trichomoniasis may be due primarily to the Inca dove (*Columbina inca*), an urban obligate that composes significant part of the diet of urban Cooper's hawks. However, the prevalence of this disease is null or very low among rural nestlings (Boal et al. 1998; Boal and Mannan 1999), which confirms the problem of urban coexistence of parasite hosts (that in general are very abundant) and raptors that can be infected by a variety of diseases. West Nile virus is a mosquito-borne infection with birds being most commonly infected and serving as prime hosts. This virus has been detected among a large number of raptors (Marra et al. 2004; Nemeth et al. 2007; Dusek et al. 2010; Quaglia et al. 2014). Urban and suburban settings provide numerous oviposition sites for mosquitoes. These environments can be important sites to maintain West Nile virus. Several species of urban or suburban raptors positive to West Nile virus have been detected in southeastern Wisconsin, USA (great horned owl *Bubo virginianus*, red-tailed hawk *Buteo jamaicensis*, and Cooper's hawk, Stout et al. 2005) and in Córdoba and Tucumán Argentine (rufous-thighed hawk *Accipiter erythronemius* and American kestrel *Falco sparverius*, Diaz et al. 2011).

Vehicle collision is a major cause of mortality for urban raptors (Donázar et al. 2016). For burrowing owls in an urbanized area of Cape Coral, Florida, vehicle collision was the cause of death for 70% of owl mortality; the same is true for urban bald eagles in Florida (Millsap 2002; Millsap et al. 2004) and Cooper's hawks in Arizona (Boal and Mannan 1999). Nevertheless authors could not envision any viable method in reducing the incidence of collisions with vehicles. While one death by collision was reported, this threat did not seem to be a big problem for Cooper's hawks in an urban environment in Indiana, USA (Roth et al. 2005).

Deaths from collision and electrocution with power lines are an important threat to raptors due to their behavior and size (Rubolini et al. 2005, in this book Chap. 12). Electrocution have been considered as an important source of mortality for raptors breeding in urbanized areas of Arizona, USA (Dwyer 2004). Although collisions are difficult to detect since birds may only be injured and survive to the incident, the potential for collisions with power lines increases with the development of electrical distribution infrastructure. Collision and electrocution risks are higher at specific sites with great development of poles and power lines. In cities, these sites are relatively easy to identify, and retrofitting lethal electric poles can reduce the number of electrocution incidents (Dwyer and William Mannan 2007, in this book Chap. 12). Despite efforts to design mitigation measures against these threats, this problem is not yet resolved (Dwyer 2004).

References

Beissinger S, Donnay T, Walton R (1994) Experimental analysis of diet specialization in the snail kite: the role of behavioral conservatism. Oecologia (100):54–65. https://doi.org/10.1007/BF00317130

Bellocq M, Filloy J, Garaffa P (2008) Influence of agricultural intensity and urbanization on the abundance of the raptor chimango caracara (*Milvago chimango*) in the Pampean region of Argentina. Ann Zool Fenn 45:128–134

Berry M, Bock C, Haire S (1998) Abundance of diurnal raptors on open space grasslands in an urbanized landscape. Condor 100:601–608. Available at: http://hairelab.com/files/Berry-etal1998.pdf [Verified 9 May 2014]

Biondi L, Bó M, Vassallo A (2008) Experimental assessment of problem solving by *Milvago chimango* (Aves: Falconiformes). J Ethol 26:113–118. https://doi.org/10.1007/s10164-007-0035-2

Biondi L, Bó M, Vassallo A (2010a) Inter-individual and age differences in exploration, neophobia and problem-solving ability in a Neotropical raptor (*Milvago chimango*). Anim Cogn 13:701–710. https://doi.org/10.1007/s10071-010-0319-8

Biondi L, García G, Bó M, Vassallo A (2010b) Social learning in the Caracara Chimango, *Milvago chimango* (Aves: Falconiformes): an age comparison. Ethology 116:1–14. https://doi.org/10.1111/j.1439-0310.2010.01794.x

Biondi L, Guido J, Madrid E, Bó M, Vassallo A (2013) The effect of age and sex on object exploration and manipulative behavior in a neotropical raptor, the Chimango Caracara, *Milvago chimango*. Ethology 119:221–232. https://doi.org/10.1111/eth.12056

Biondi L, Guido J, Bó M, Muzio R, Vassallo A (2015) The role of stimulus complexity, age and experience in the expression of exploratory behaviour in the Chimango Caracara, *Milvago chimango*. Anim Cogn 18:139–150. https://doi.org/10.1007/s10071-014-0785-5

Blair RB (1996) Land use and avian species diversity along an urban gradient. Ecol Appl 6:506–519

Blumstein D (2006) Developing an evolutionary ecology of fear: how life history and natural history traits affect disturbance tolerance in birds. Anim Behav 71:389–399. https://doi.org/10.1016/j.anbehav.2005.05.010

Blumstein DT, Anthony LL, Harcourt R, Ross G (2003) Testing a key assumption of wildlife buffer zones: is flight initiation distance a species-specific trait? Biol Conserv 110:97–100. https://doi.org/10.1016/S0006-3207(02)00180-5

Boal CW, Mannan RW (1999) Comparative breeding ecology of Cooper's hawks in urban and exurban areas of southeastern Arizona. J Wildl Manag 63:77. https://doi.org/10.2307/3802488

Boal CW, Mannan RW, Hudelson KS (1998) Trichomoniasis in Cooper's hawks from Arizona. J Wildl Dis 34:590–593. https://doi.org/10.7589/0090-3558-34.3.590

Bond G, Burnside NG, Metcalfe DJ, Scott DM, Blamire J (2005) The effects of land-use and landscape structure on barn owl (*Tyto alba*) breeding success in southern England, U.K. Landsc Ecol 20:555–566. https://doi.org/10.1007/s10980-004-5037-7

Botelho E, Arrowood P (1996) Nesting success of western burrowing owls in natural and human-altered environments. In: Bird CD, Verlan DE, Negro JJ (eds) Raptors in human landscapes: adaptations to built and cultivated environments. Academic Press Limited, New York, pp 61–68

Bradley CA, Altizer S (2007) Urbanization and the ecology of wildlife diseases. Trends Ecol Evol 22:95–102. https://doi.org/10.1016/j.tree.2006.11.001

Carrete M, Tella J (2010) Individual consistency in flight initiation distances in burrowing owls: a new hypothesis on disturbance-induced habitat selection. Biol Lett 6:167–170. https://doi.org/10.1098/rsbl.2009.0739

Carrete M, Tella J (2011) Inter-individual variability in fear of humans and relative brain size of the species are related to contemporary urban invasion in birds. PLoS One 6:e18859. https://doi.org/10.1371/journal.pone.0018859

Carrete M, Tella J (2013) High individual consistency in fear of humans throughout the adult lifespan of rural and urban burrowing owls. Sci Rep 3:3524. https://doi.org/10.1038/srep03524

Carrete M, Tella JL (2017) Behavioral correlations associated with fear of humans differ between rural and urban burrowing owls. Front Ecol Evol 5. https://doi.org/10.3389/fevo.2017.00054

Carrete M, Tella J, Blanco G, Bertellotti M (2009) Effects of habitat degradation on the abundance, richness and diversity of raptors across Neotropical biomes. Biol Conserv 142:2002–2011. https://doi.org/10.1016/j.biocon.2009.02.012

Carrete M, Martínez-Padilla J, Rodríguez-Martínez S, Rebolo-Ifrán N, Palma A, Tella JL (2016) Heritability of fear of humans in urban and rural populations of a bird species. Sci Rep 6:31060. https://doi.org/10.1038/srep31060

Cava JA, Stewart AC, Rosenfield RN (2012) Introduced species dominate the diet of breeding urban Cooper's hawks in British Columbia. Wilson J Ornithol 124:775–782. https://doi.org/10.2307/23324528

Cavalli M, Baladrón AV, Isacch JP, Biondi LM, Bó MS (2016) Differential risk perception of rural and urban burrowing owls exposed to humans and dogs. Behav Process 124:60–65. https://doi.org/10.1016/j.beproc.2015.12.006

Chace J, Walsh J (2006) Urban effects on native avifauna: a review. Landsc Urban Plan 74:46–69. https://doi.org/10.1016/j.landurbplan.2004.08.007

Cooke AS (1980) Observations on how close certain passerine species will tolerate an approaching human in rural and suburban areas. Biol Conserv 18:85–88. https://doi.org/10.1016/0006-3207(80)90072-5

Cusa M, Jackson DA, Mesure M (2015) Window collisions by migratory bird species: urban geographical patterns and habitat associations. Urban Ecosys 18:1427–1446. https://doi.org/10.1007/s11252-015-0459-3

Diaz L, Quaglia A, Flores F, Contigiani M (2011) Virus West Nile en Argentina: un agente infeccioso. Hornero 26:5–28

Díaz M, Møller AP, Flensted-Jensen E, Grim T, Ibáñez-Álamo JD, Jokimäki J, Markó G, Tryjanowski P (2013) The geography of fear: a latitudinal gradient in anti-predator escape distances of birds across Europe. PLoS One 8. https://doi.org/10.1371/journal.pone.0064634

Donázar JA, Cortés-Vizanda A, Fargallo JA, Margalida A, Moleón M, Morales-Reyes Z, Moreno-Opo R, Pérez-Garcia JM, Sanchez-Zapata JA, Zuberogoitia I, Serrano D (2016) Roles of raptors in a changing world: from flagships to providers of key ecosystem services. Ardeola 63:181–234. https://doi.org/10.13157/arla.63.1.2016.rp8

Dusek RJ, Iko WM, Hofmeister EK (2010) Occurrence of West Nile virus infection in raptors at the Salton Sea, California. J Wildl Dis 46:889–895. https://doi.org/10.7589/0090-3558-46.3.889

Dwyer JF (2004) Investigating and mitigating raptor electrocution in an urban environment. MSc Thesis, University of Arizona, Tucson

Dwyer JF, William Mannan R (2007) Preventing raptor electrocutions in an urban environment. J Rap Res 41:259–267. https://doi.org/10.3356/0892-1016(2007)41[259:PREIAU]2.0.CO;2

Dykstra CR, Hays JL, Simon MM (2009) Spatial and temporal variation in reproductive rates of the red-shouldered hawk in suburban and rural Ohio. Condor 111:177–182. https://doi.org/10.1525/cond.2009.080002

Evans J, Boudreau K, Hyman J (2010) Behavioural syndromes in urban and rural populations of song sparrows. Ethology 116:588–595. https://doi.org/10.1111/j.1439-0310.2010.01771.x

Ferguson HL (2004) Winter raptor composition, abundance and distribution around urban Spokane, eastern Washington. In: Shaw WW, Harris LK, VanDruff L (eds) 4th international symposium on urban wildlife conservation. University of Arizona, Tucson, p 368

Fraser JD, Frenzel LD, Mathisen JE (1985) The impact of human activities on breeding bald eagles in north-Central Minnesota. J Mammal 49:585–592

Gehlbach F (1996) Eastern screech owls in suburbia: a model of raptor urbanization. In: Raptors in human landscapes adaptations to built and cultivated environments. Academic Press, London, pp 69–74

Gliwicz J, Goszczynski J, Luniak M (1994) Characteristic features of animal populations under synurbanization - the case of the blackbird and of the striped field mouse. Memorabi Zool 49:237–244

Guido JM, Biondi LM, Vasallo AI, Muzio RN (2017) Neophobia is negatively related to reversal learning ability in females of a generalist bird of prey, the Chimango Caracara, *Milvago chimango*. Anim Cogn. https://doi.org/10.1007/s10071-017-1083-9

Hager SB (2009) Human-related threats to urban raptors. J Rap Res 43:210–226. https://doi.org/10.3356/JRR-08-63.1

Hager SB, Craig ME (2014) Bird-window collisions in the summer breeding season. PeerJ 2:e460. https://doi.org/10.7717/peerj.460

Haiman, A (2006). Prey selection of Cooper's hawks (*Accipiter cooperii*) nesting in urban areas of Berkeley and Albany, California , 1–13

Hogg JR, Nilon CH (2015) Habitat associations of birds of prey in urban business parks. Urban Ecosys 18:267–284. https://doi.org/10.1007/s11252-014-0394-8

Kauffman MJ, Pollock JF, Walton B (2004) Spatial structure, dispersal, and management of a recovering raptor population. Am Nat 164(5):582–597

Kübler S, Kupko S, Zeller U (2005) The kestrel (*Falco tinnunculus* L.) in berlin: investigation of breeding biology and feeding ecology. J Ornithol 146:271–278. https://doi.org/10.1007/s10336-005-0089-2

Lin T, Coppack T, Lin QX, Kulemeyer C, Schmidt A, Behm H, Luo T (2012) Does avian flight initiation distance indicate tolerance towards urban disturbance? Ecol Indic 15:30–35. https://doi.org/10.1016/j.ecolind.2011.09.018

Marra PP, Griffing S, Caffrey C, Kilpatrick MA, McLean R, Brand C, Saito E, Dupuis AP, Kramer L, Novak R (2004) West Nile virus and wildlife. Bioscience 54:393–402. https://doi.org/10.1641/0006-3568(2004)054[0393:WNVAW]2.0.CO;2

Martínez-Abraín A, Oro D, Conesa D, Jiménez J (2008) Compromise between seabird enjoyment and disturbance: the role of observed and observers. Environ Conserv 35:104–108. https://doi.org/10.1017/S0376892908004748

Marzluff JM (2017) A decadal review of urban ornithology and a prospectus for the future. Ibis 159:1–13. https://doi.org/10.1111/ibi.12430

Marzluff JM, Bowman R, Donnelly R (2001) Avian ecology and conservation in an urbanizing world. Kluwer Academic Publishers, Boston

McKinney M (2002) Urbanization, biodiversity, and conservation. Bioscience 52:883–890

McPherson SC, Brown M, Downs CT (2016) Crowned eagle nest sites in an urban landscape: requirements of a large eagle in the Durban metropolitan open space system. Landsc Urban Plan 146:43–50

Millsap BA (2002) Survival of Florida burrowing owls along an urban-development gradient. J Rap Res 36:3–10

Millsap BA, Bear C (2000) Density and reproduction of burrowing owls along an urban development gradient. J Wildl Manag 64:33–41. https://doi.org/10.2307/3802972

Millsap B, Breen T, McConnell E, Steffer T, Phillips L, Douglass N, Taylor S (2004) Comparative fecundity and survival of bald eagles fledged from suburban and rural natal areas in Florida. J Wildl Manag 68:1018–1031. https://doi.org/10.2193/0022-541X(2004)068[1018:CFASOB]2.0.CO;2

Møller AP (2008) Flight distance of urban birds, predation, and selection for urban life. Behav Ecol Sociobiol 63:63–75. https://doi.org/10.1007/s00265-008-0636-y

Møller A (2009) Successful city dwellers: a comparative study of the ecological characteristics of urban birds in the western Palearctic. Oecologia 159:849–858

Møller AP (2010) Interspecific variation in fear responses predicts urbanization in birds. Behav Ecol 21:365–371. https://doi.org/10.1093/beheco/arp199

Muhly TB, Semeniuk C, Massolo A, Hickman L, Musiani M (2011) Human activity helps prey win the predator-prey space race. PLoS One 6:1–8. https://doi.org/10.1371/journal.pone.0017050

Nemeth N, Kratz G, Edwards E, Scherpelz J, Bowen R, Komar N (2007) Surveillance for West Nile virus in clinic-admitted raptors, Colorado. Emerg Infect Dis 13:305–307. https://doi.org/10.3201/eid1302.051626

Newton, I (1979). ‘Population ecology of raptors’ Ed I. Newton. (T & AD Poyser: London.) Available at: http://books.google.com/books?hl=en&lr=&id=J39XMu7ecjAC&oi=fnd&pg=PP2&dq=Population+ecology+of+raptors&ots=XZ84xVGWX_&sig=eHMuBrUe2lVOPumBJHVN3gZA32Y [Verified 25 July 2014]

Newton I (1998) In: Newton I (ed) Population limitation in birds. Academic Press Limited, San Diego

Parker JW (1996) Urban ecology of the Mississippi kite. In: Bird CD, Verlan DE, Negro JJ (eds) Raptors in human landscapes. Adaptation to built and cultivate environments. New York, Academic Press Limited, pp 45–52

Pedrana J, Isacch J, Bó M (2008) Habitat relationships of diurnal raptors at local and landscape scales in southern temperate grasslands of Argentina. Emu 108:301–310

Quaglia AI, Diaz LA, Argibay H, Contigiani MS, Saggese MD (2014) West Nile and St. Louis encephalitis viruses antibodies surveillance in captive and free-ranging birds of prey from Argentina. EcoHealth 11:603–609. https://doi.org/10.1007/s10393-014-0956-5

Rebolo-Ifrán N, Carrete M, Sanz-Aguilar A, Rodríguez-Martínez S, Cabezas S, Marchant TA, Bortolotti GR, Tella JL (2015) Links between fear of humans, stress and survival support a non-random distribution of birds among urban and rural habitats. Sci Rep 5:13723. https://doi.org/10.1038/srep13723

Rebolo-Ifrán N, Tella JL, Carrete M (2017) Urban conservation hotspots: predation release allows the grassland-specialist burrowing owl to perform better in the city. Sci Rep 7:1–9. https://doi.org/10.1038/s41598-017-03853-z

Rodriguez-Prieto I, Fernández-Juricic E, Martín J, Regis Y (2009) Antipredator behavior in blackbirds: habituation complements risk allocation. Behav Ecol 20:371–377. https://doi.org/10.1093/beheco/arn151

Rose S, Sumasgutner P, Koeslag A, Amar A (2017) Does seasonal decline in breeding performance differ for an African raptor across an urbanization gradient? Front Ecol Evol 5:1–9. https://doi.org/10.3389/fevo.2017.00047

Rosenfield RN, Bielefeldt J, Affeldt JL, Beckmann DJ (1995) Nesting density, nest area reoccupancy, and monitoring implications for Cooper’s hawks in Wisconsin. J Rap Res 29:1–4

Rosenfield RN, Bielefeldt J, Rosenfield LJ, Taft SJ, Murphy RK, Stewart AC, Rosenfield RN, Bielefeldt J, Rosenfield LJ, Taft SJ, Murphy RK, Stewart AC (2002) Prevalence of *Trichomonas gallinae* in nestling Cooper’ s hawks among three north American populations. Wilson Bull 114:145–147

Rosenfield RN, Taft SJ, Stout WE, Driscoll TG, Evans DL, Bozek M a (2009) Low prevalence of *Trichomonas gallinae* in urban and migratory Cooper’s hawks in northcentral North America. Wilson J Ornithol 121:641–644. https://doi.org/10.1676/08-148.1

Roth TC, Lima SL, Vetter WE (2005) Survival and causes of mortality in wintering sharp-shinned hawks and Cooper’s hawks. Wilson Bull 117:237–244. https://doi.org/10.1676/04-103.1

Rubolini D, Gustin M, Bogliani G, Garavaglia R (2005) Birds and powerlines in Italy: an assessment. Bird Conserv Int 15:131–145. https://doi.org/10.1017/S0959270905000109

Rudd H, Vala J, Schaefer V (2002) Importance of backyard habitat in a comprehensive biodiversity conservation strategy: a connectivity analysis of urban green spaces. Restor Ecol 10:368–375. https://doi.org/10.1046/j.1526-100X.2002.02041.x

Rullman S, Marzluff JM (2014) Raptor presence along an urban – wildland gradient: influences of prey abundance and land cover. J Rap Res 48:257–272. https://doi.org/10.3356/JRR-13-32.1

Samia DSM, Nakagawa S, Nomura F, Rangel TF, Blumstein DT (2015) Increased tolerance to humans among disturbed wildlife. Nat Commun 6:8877. https://doi.org/10.1038/ncomms9877

Schlaepfer M, Runge M, Sherman P (2002) Ecological and evolutionary traps. Trends Ecol Evol 17:474–480. https://doi.org/10.1016/S0169-5347(02)02580-6

Sol D, Lefebvre L (2000) Behavioural flexibility predicts invasion success in birds introduced to New Zealand. Oikos 90:599–605. Available at: http://onlinelibrary.wiley.com/doi/10.1034/j.1600-0706.2000.900317.x/full [Verified 27 February 2014]

Sol D, Timmermans S, Lefebvre L (2002) Behavioural flexibility and invasion success in birds. Anim Behav 63:495–502. https://doi.org/10.1006/anbe.2001.1953

Sol D, Duncan R, Blackburn T, Cassey P, Lefebvre L (2005) Big brains, enhanced cognition, and response of birds to novel environments. Proc Natl Acad Sci 102:5460–5465. Available at: http://www.pnas.org/content/102/15/5460.short [Verified 27 February 2014]

Sol D, Griffin A, Bartomeus I, Boyce H (2011) Exploring or avoiding novel food resources? The novelty conflict in an invasive bird. PLoS One 6:e19535. https://doi.org/10.1371/journal.pone.0019535

Solaro C (2015) Ecología y comportamiento del chimango (*Milvago chimango*) en ambientes antropizados del centro de Argentina. PhD Thesis, Universidad Nacional del Comahue, Neuquén, Argentina

Solaro C, Sarasola JH (2015) Nest-spacing, not human presence, influences the breeding of Chimango caracaras (*Milvago chimango*) in a peri-urban reserve. Emu 115:72–75. https://doi.org/10.1071/MU14038

Solaro C, Sarasola JH (2017) Natal dispersal and philopatry of Chimango caracaras (*Milvago chimango*) in suburban, rural and natural habitats, determined by band recovery and re-sighting data. Emu 118:158–165. https://doi.org/10.1080/01584197.2017.1321961.

Stout W, Anderson RK, Papp JM (1998) Urban, suburban and rural red-tailed hawk nesting habitat and populations in Southeast Wisconsin. J Rap Res 32:221–228. https://doi.org/10.1080/00958970600794008

Stout WE, Cassini AG, Meece JK, Papp JM, Rosenfield RN, Reed KD (2005) Serologic evidence of West Nile virus infection in three wild raptor populations. Avian Dis 49:371–375. https://doi.org/10.1637/7335-012805R1.1

Stout W, Temple S, Papp J (2006) Landscape correlates of reproductive success for an urban-suburban red-tailed hawk population. J Wildl Manag 70:989–997

Sumasgutner P (2013) Diet specialisation and breeding success along an urban gradient: the kestrel (*Falco tinnunculus*) in Vienna, Austria. Beiträge Zur Jagd Und Wildforschung 38:385–397

Sumasgutner P, Schulze CH, Krenn HW, Gamauf A (2014a) Conservation related conflicts in nest-site selection of the Eurasian kestrel (*Falco tinnunculus*) and the distribution of its avian prey. Landsc Urban Plan 127:94–103. https://doi.org/10.1016/j.landurbplan.2014.03.009

Sumasgutner P, Nemeth E, Tebb G, Krenn H, Gamauf A (2014b) Hard times in the city – attractive nest sites but insufficient food supply lead to low reproduction rates in a bird of prey. Front Zool 11:48. https://doi.org/10.1186/1742-9994-11-48

Sumasgutner P, Millán J, Curtis O, Koelsag A, Amar A (2016) Is multiple nest building an adequate strategy to cope with inter-species nest usurpation? BMC Evol Biol 16:97. https://doi.org/10.1186/s12862-016-0671-7

Tella J, Hiraldo F, Donázar-Sancho J, Negro J (1996) Costs and benefits of urban nesting in the lesser kestrel. In: Bird CD, Verlan DE, Negro JJ (eds) Raptors in human landscapes: adaptations to built and cultivated environments. Academic Press Limited, New York, pp 53–60