Chapter 7
Warning! Urban Threats for Birds in Latin America

Diego Santiago-Alarcon and Carlos A. Delgado-V

Abstract Wild birds are subject to a diverse array of natural causes of mortality, such as predation and parasitism. However, anthropogenic sources are becoming major threats for birds, particularly in urban systems, where major ecological impacts can affect both intra- and interspecific interactions. For instance, host-parasite interactions are modified in such a way that parasites can start appearing in novel hosts and generate health problems. Furthermore, nonnative predators can severely affect bird populations, at times driving them locally extinct when occurring in combination with the reduction of suitable sites. In this chapter, we show that urbanization entails such drastic alterations on the environment that antagonistic interactions can become an important threat to birds. Predation by cats has been identified as the most important threat to urban birds, accounting for up to billions of deaths annually in the USA alone, followed by bird collisions with building structures. Our review reveals a lack of knowledge related to the main urban bird threats in Latin America. The available information suggests that cats and collisions with building structures and vehicles might also be major sources of bird mortality in the region. However, it is premature to make generalizations at this stage because Latin American cities develop differently and are immersed in diverse socioecological contexts (i.e., different cultural habits imposed by local environmental conditions). We suggest that systematic studies in urban Latin America should focus on three main areas: (i) predation by cats; (ii) building and vehicle collisions; and (iii) alterations of host-parasite interactions.

Keywords Avian parasitology • Building collisions • Host-parasite interactions • Urban ecology • Urban predators

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7.1 Global Perspective

In wild bird populations, mortality can result from regular ecological dynamics, such as density-dependent events that determine the size of a population in a given locality (e.g., population carrying capacity; Stevens 2009). Furthermore, mortality also occurs from interspecific interactions such as parasitism (Palinauskas et al. 2008), as well as from direct and indirect anthropogenic causes (e.g., pollution, habitat destruction, domestic animal predation, collisions; Erickson et al. 2005; Loss et al. 2015). These anthropogenic factors are becoming the most worrisome threats around the globe because they translate into billions of bird deaths annually. However, apart from the USA and Canada in North America, the UK in Europe, and Australia and New Zealand in Oceania, information on bird mortality from anthropogenic causes is scarce or inexistent (Loss et al. 2015). Additionally, there is a similar lack of parasitological studies of wild birds in anthropogenically modified systems (Delgado-V and French 2012; Hernández-Lara et al. 2017).

The main anthropogenic causes of wild bird mortality in urban areas of the USA and Canada, where most information is available, are predation by cats, collisions with building windows, and vehicles (Loss et al. 2015; Table 7.1); yet, the dearth of knowledge of avian parasitism in urban areas does not allow us to gauge the impact of altering host-parasite interactions by anthropogenic factors on bird health. Cats have decimated bird populations on small islands (Nogales et al. 2013) and are estimated to kill, based on statistical extrapolations, between one and four billion wild birds annually in the USA alone (Loss et al. 2013). In Canada, the estimate ranges from 100 to 350 million birds killed by cats (Blancher 2013), of which ~186 million are breeding individuals (Calvert et al. 2013). There is little information on the numbers of birds killed by cats in terms of bird species or avian guilds, and on the negative impacts that such a factor has on wild bird populations, particularly those of

Table 7.1 Estimates of bird mortality from anthropogenic urban factors in the USA and Canada

Mortality source[a]	Estimate	95% CI	Country
Cat predation	2,407,000,000	1,306,000,000–3,992,000,000	USA
	204,000,000	105,000,000–348,000,000	Canada
Building collisions	599,000,000	365,000,000–988,000,000	USA
	24,900,000	16,100,000–42,200,000	Canada
Vehicle collisions	199,600,000	88,700,000–339,800,000	USA
	13,810,906	8,914,341–18,707,470	Canada
Power line collisions	22,800,000	7,700,000–57,300,000	USA
	25,600,000	10,100,000–41,200,000	Canada
Power line electrocutions	5,630,000	920,000–11,550,000	USA
	481,399	160,836–801,962	Canada

Data source: Loss et al. (2015)

[a]Estimates are mortalities for individual birds; they do not include destroyed nests, eggs, and nestlings

conservation concern (e.g., Loyd et al. 2013). In Canada, land birds are the group suffering higher impacts, mainly species foraging on the ground, using winter feeders, and nesting on or close to the ground (Blancher 2013; Calvert et al. 2013). The reduction of cat predation on birds has been suggested to be easily implemented for pets, via environmental education programs, but for feral cats, control can be controversial when it implies lethal control due to its social implications (McCarthy et al. 2012; Loss et al. 2015).

Bird mortality by collision with building structures (mostly windows) in the USA and Canada ranges from 16 million to close to a billion individuals (Machtans et al. 2013; Loss et al. 2014a). Long-distance migrant species, some of conservation concern, are the most vulnerable group to this threat, particularly during the migration period that contrasts with the low mortality rates recorded in urban-dwelling species (Arnold and Zink 2011). Although limited, some strategies have already been implemented in the USA to reduce window collisions, for example, by using UV reflecting surfaces (Klem and Saenger 2013), and by placing patterns and objects on the exterior surface to reduce reflective window area (Klem et al. 2009). Others suggest that such methods serve as attractants, instead of deterring visitation by birds; however, they argue that due to this attraction, birds would be aware of windows reducing collision likelihood (Habberfield and Clair 2016). Another major type of avian collision is that with vehicles, which ranges from 13 to more than 300 million deaths per year in the USA and Canada (Bishop and Brogan 2013; Loss et al. 2014b). Scarce information exists regarding avian groups at greater risk, how mortality varies as a function of road features, and there are woefully no tested strategies to reduce this mortality risk (Loss et al. 2015).

Other sources of mortality include the collision with communication towers, wind turbines, and power lines (electrocution included), which generate bird deceases in the range of 200,000 to more than 50 million altogether (Longcore et al. 2012; Loss et al. 2013, 2015; Smallwood 2013). Some of these estimates are reliable given that they took into account sources of bias such as scavenging rates, search efficiency, and sampling effort (Longcore et al. 2012). When focusing on collisions with communication towers, it has been reported that the annual mortality from this source might represent >1% of their entire populations in some species, of which apparently migratory songbirds are at greater risk (Loss et al. 2015). The factors that seem to be most relevant for increased risk of bird mortality are tower height, turbine placement, power lines materials and placement, and signaling red lights at towers (Manville 2009; Loss et al. 2015). Bird mortality seems to be low at wind facilities compared to other sources, but the current and rapid expansion of wind energy might substantially increase current estimates up to a fourfold in the USA within the next 20 years (Loss et al. 2015). Hence, it is of the highest relevance to continue, improve, and expand bird surveys in relation to the design and construction of wind farms.

Different to the other mentioned major threats, parasitism is a natural process that has shown to be one of the most successful ways of life on Earth, which has independently evolved in animals at least 60 times (Poulin and Morand 2000; Poulin 2007). However, parasites do not necessarily spell disaster (as often perceived), they actually are essential for healthy, functional ecosystems (Marcogliese 2005; Lafferty et al. 2008). Major problems with parasites result when they become pathogens (i.e., parasites that generate health problems in their hosts), which can be due to a weakened immune system or environmental changes (e.g., Hamer et al. 2012). Currently, the main parasitological challenges from the medical and veterinary trenches are the rapid modifications ensued by anthropogenic activities, which are behind global viral outbreaks (Jones et al. 2008; Aguirre et al. 2012). For example, biodiversity loss opens opportunities for novel host-parasite associations, which can result in epidemics (e.g., West Nile virus, amphibian viruses; Kilpatrick et al. 2006; Johnson et al. 2013).

Urbanization, considered a major threat to biodiversity, is known to alter the ecology of wildlife pathogens (Bradley and Altizer 2007; Shochat et al. 2010). By modifying among-species contact rates, urbanization changes parasite abundance and distribution by altering vector-feeding preferences (e.g., avian malaria; Santiago-Alarcon et al. 2012, 2013). Despite their relevance, parasitological studies in urbanized areas are scarce and far behind projects involving macroorganisms such as birds and mammals (e.g., MacGregor-Fors et al. 2015), limiting our capacity to understand the ecological patterns and processes in urban ecosystems from the parasitological standpoint (Delgado-V and French 2012; Martin and Boruta 2014; Santiago-Alarcon et al. 2016; Carbó-Ramírez et al. 2017). For instance, for vector-borne avian parasites, the information is limited to lists of pathogens and some of their effects on urban-dwelling birds (e.g., Rock Pigeon – *Columba livia*, House Sparrow – *Passer domesticus*; Delgado-V and French 2012). In addition, there is no common pattern in infection rates when comparing urban and nonurban conditions at different geographical locations, either for the same or for different bird species; some bird species have higher infection rates in urban compared to nonurban counterparts, and the opposite pattern can be observed for the same species at other localities (Fokidis et al. 2008; Evans et al. 2009; Hernández-Lara et al. 2017; Table 7.2). Urbanization effects are complex and might be site-, parasite-, and host-specific (Martin and Boruta 2014; Delgado-V and French 2015). Thus, parasitological studies in urban systems with proper controls (i.e., nonurban well-preserved regional system) will clarify the relationship between urbanization and host-parasite ecological dynamics (Hernández-Lara et al. 2017).

Despite current efforts, the impact of the above mentioned factors on urban bird populations need to be better gauge, particularly for specific groups of birds (e.g., Nearctic-Neotropical migrants, geographically restricted species; Erickson et al. 2005). Reasons include nonstandardized sampling methods, observation biases, and scavenging rates, all of which vary as a function of avian group, ecosystem, and seasonality (Erickson et al. 2005; Loss et al. 2015). Hence, the implementation of random and representative number of experimental units along with standardized sampling methods is necessary to define the real impact of the factors mentioned above on birds. Furthermore, detection and removal (scavenging) rates must be estimated at each study site because local conditions will certainly change the quantification of mortalities, which are necessary to adjust impact estimates (Erickson et al. 2005).

Table 7.2 Prevalence (i.e., proportion of infected birds in a sample) estimates from studies on avian parasites conducted in different parts of the world that include at least one urban and nonurban comparison

	Blood parasite prevalence (%)		
City (country)	Urban	Nonurban	Source[a]
Munich (Germany) – Spring	58	73	Geue and Partecke (2008)
Munich (Germany) – Summer	75	100	Geue and Partecke (2008)
Phoenix (USA)	0	44	Fokidis et al. (2008)
Phoenix (USA)	22	0	Fokidis et al. (2008)
Phoenix (USA)	23	39	Fokidis et al. (2008)
Phoenix (USA)	0	0	Fokidis et al. (2008)
Berlin (Germany)	62	95	Evans et al. (2009)
Groningen (Germany)	90	75	Evans et al. (2009)
Krakow (Poland)	78	75	Evans et al. (2009)
Madrid (Spain)	25	78	Evans et al. (2009)
Valencia (Spain)	38	80	Evans et al. (2009)
Prague (Czech Republic)	82	90	Evans et al. (2009)
Riga (Latvia)	62	63	Evans et al. (2009)
Sheffield (England)	43	83	Evans et al. (2009)
Tallinn (Estonia)	58	39	Evans et al. (2009)
Tunis (Tunisia)	80	98	Evans et al. (2009)
Xalapa (México)	63	38	Hernández-Lara et al. (2017)

[a]Prevalence values are approximate rounded figures acquired from cited sources

7.2 Latin American Studies

In this section, we review studies related to the potential threats imposed by urbanization to birds in Latin American cities. For this, we searched for publications in the Web of Science (www.webofknowledge.com) and Scopus (www.scopus.com) platforms using the following keywords in both English and Spanish: 'bird,' 'avian,' 'urban,' 'Latin America.' We also searched for theses and dissertations in databases from major Latin American universities (e.g., National Autonomous University of Mexico – UNAM, University of São Paulo – USP, National University of Colombia – UNAL). Finally, we consulted urban ecology and urban threat-related expert colleagues from Latin America for further additional publications that could enrich our review.

7.2.1 Exotic, Invasive, and Domestic Predators

With human populations increasing worldwide along with the lack of proper regulatory measures to own pets in most Latin American countries, domestic cat populations are likely growing in parallel, a situation that might bring associated risks to local wildlife (e.g., van Heezik et al. 2010). Although there is no available published information that documents the effects of cats on urban wildlife in Latin America, there are initial efforts to gather information, such as Aburrá Natural (www.aburra-natural.org), which has been collecting data about cat predation in Medellín, Colombia. Preliminary results show that cat predation is more prevalent at the interior of the urban area (68%, $n = 25$ kills, average kills = 0.002/ha) when compared to its periphery and natural areas ($n = 11$ kills, average kills = 0.0004/ha). At least 20 bird species have been recorded to be depredated by cats, including young individuals of the endemic Colombian Chachalaca (*Ortalis columbiana*) and the near-endemic Scrub Tanager (*Tangara vitriolina*).

In Mexico, we found a study analyzing the diet of both domestic and feral cats in an urbanization intensity gradient of the city of Morelia. Small mammals and reptiles comprised most of the studied cat diet in the urban and nonurban environments; only in pine-oak forests, birds became dominant. When cat scats were analyzed, small mammals remained as the main item of cat diet in the urban environment, with birds and reptiles representing a minor proportion (Orduña-Villaseñor 2015). Results from this study suggest that cats prefer mammals instead of birds in Morelia, which might be unexpected given information from other countries (e.g., Loss et al. 2015). Based on this study, we suggest that a larger array of potential preys, given by the biodiversity present in tropical latitudes, could explain the contrasting pattern to what is known from temperate regions.

Regarding dogs, they might also be implicated as a factor threatening birds in urbanized landscapes. For instance, the occurrence of dogs might be one of the causes of unsuccessful nesting of the Spot-flanked Gallinule (*Porphyriops melanops*) in a channel of pluvial drainages connected to urban wetlands (Becerra-Galindo et al. 2005). In Mexico, a study conducted in three cities of the state of Michoacán showed that dog numbers are negatively associated with the diversity of moderately abundant and rare bird species, suggesting that feral and off-leash dogs are stressful agents and potential bird predators in cities (MacGregor-Fors and Schondube 2011). Additionally, there is a growing evidence of records of free-ranging domestic dogs within and around South American cities, for instance, in Medellín and Bogota; however, their local effects on birds and other wildlife remain unstudied (Delgado-V pers. obs.).

7.2.2 Collision with Building Structures

Information regarding collisions with building windows is receiving a growing, yet still scarce, scientific attention in Latin America (Cupul-Magaña 2003; Agudelo-Álvarez 2006; Agudelo-Álvarez et al. 2010; Menacho-Odio 2015; Oviedo 2014). Different species, sizes, and feeding guilds, from hummingbirds to chachalacas (e.g., Colombian Chachalaca; Fig. 7.1; Delgado-V pers. obs.), have been recorded crashing on windows. In particular, many collisions correspond to Nearctic-Neotropical migrants, such as the Yellow-breasted Chat (*Icteria virens*),

Fig. 7.1 Fatal collision of a Colombian Chachalaca (*Ortalis columbiana*) on a building located at Universidad CES, Medellín, Colombia (Photo: Hana Londoño)

Ruby-throated Hummingbird (*Archilochus colubris*), as well as Indigo Bunting (*Passerina cyanea*; M. A. Gómez-Martínez per. comm.; Fig. 7.2) in Xalapa (Mexico), and Swainson's Thrush (*Catharus ustulatus*), Northern Waterthrush (*Parkesia noveboracensis*), and Mourning Warbler (*Geothlypis philadephia*) in Medellín (Colombia). In Bogota, Colombia, approximately 88% of recorded collisions are fatal, and the most frequent group to collide are also Nearctic-Neotropical migrants (Agudelo-Álvarez 2006), such as the Red-eyed Vireo (*Vireo olivaceus*), Swainson's Thrush, Scarlet Tanager (*Piranga olivacea*), and Summer Tanager (*Piranga rubra*). Window collisions have been recorded to be more frequent in buildings located near urban greenspaces in Mexico and Colombia (Cupul-Magaña 2003; Agudelo-Álvarez et al. 2010; Delgado-V and Correa-H. 2013). According to Ocampo-Peñuela et al. (2016), decals can prevent bird-window collisions at small nonurban Colombian residences, finding a reduction of 84% of strikes after bird decal application in ~36 m^2 of total glass area. This reduction in window collision rate might be due to the awareness of birds given certain cues on windows (e.g., decals, UV light), as suggested by Habberfield and Clair (2016).

Collisions with other type of infrastructure in urban and peri-urban areas, such as electric power lines or communication towers, have been poorly documented. However, similar to collisions with buildings, migratory birds are the most affected

Fig. 7.2 Fatal collision of a Nearctic-Neotropical migrant passerine (Indigo Bunting – *Passerina cyanea*) on a three-story building located within the city of Xalapa with important reflecting pane surface (Photo: Miguel A. Gómez-Martínez)

group by such urban structures. Álvarez-López (1993) reported that at least nine migratory species collided with towers: the Swainson's Thrush had about 76% of fatal collisions, while the remaining 24% of collisions were accounted for the Blackburnian Warbler (*Setophaga fusca*), Canada Warbler (*Cardellina canadensis*), Black-and-white Warbler (*Mniotilta varia*), Bay-breasted Warbler (*Setophaga castanea*), Northern Waterthrush, and Mourning Warbler.

7.2.3 Collisions with Vehicles

The ecology of roads in urban areas and urbanized landscapes has been poorly studied (van der Ree et al. 2009) and Latin America is not an exception. Although Brazil has history on road ecology, research of this type has been mostly conducted in nonurban landscapes (e.g., Barri 2010; Bager and da Rosa 2012; da Rosa and Bager 2012; De La Ossa-Nadjar and De La Ossa 2015). A study performed in areas surrounding Andean cities showed that mammals are the most affected vertebrate group regarding collisions with vehicles (Delgado-V 2007, 2014). However, the diversity of birds found dead by car collisions within and around Medellín

(Colombia) is growing, as suggested by previous and unpublished results (Delgado-V pers. obs.), where some endemics and vulnerable species (sensu Bird Life International 2016) have been recorded, such as the Red-bellied Grackle (*Hypopyrrhus pyrohypogaster*).

7.2.4 Parasites

Although still few, studies focused on bird parasites in urban Latin America are growing. In Brazil, Belo et al. (2011) found higher prevalence (i.e., proportion of infected birds in a sample or population sample) of parasites from the genera *Plasmodium* and *Haemoproteus* in an urban site when compared to nonurban areas. A study conducted in a Brazilian urbanization intensity gradient showed that there is a negative relationship between bird parasite species richness and the degree of urbanization (Calegaro-Marques and Amato 2014), indicating that urbanization has a negative effect on the number of parasite species, which is similar to patterns reported for other organisms like fishes and plants (Alberti 2008). However, there was a positive association between environmental heterogeneity and parasite richness, suggesting that even when urbanization can disrupt host-parasite interactions, some systems can actually benefit from the heterogeneity provided by cities (Calegaro-Marques and Amato 2014).

In Mexico, Hernández-Lara et al. (2017) found higher prevalence of *Plasmodium* parasites (Fig. 7.3) infecting Chestnut-capped Brushfinches (*Arremon brunneinucha*) in an urban greenspace compared to a peri-urban forest, a well-preserved cloud forest, a shade coffee plantation, and a cattle ranch. Carbó-Ramírez et al. (2017) compared three environmentally contrasting urban greenspaces (two in Mexico and one in Germany), finding that despite different environmental conditions and avian composition, haemosporidian assemblages had similar abundance distribution, similar infection rates, and phylogenetically diverse parasite communities (i.e., genetically different parasites) dominated by widespread generalist lineages. Finally, a comparison of urban and nonurban populations of the nonnative House Sparrow in Mexico City shows that there is a lower risk of avian malaria infections in the city, where birds tend to use highly developed areas and avoid greenspaces (Santiago-Alarcon et al. in prep.). Thus, this nonnative urban exploiter seems to have been released from its natural parasites in highly developed areas within cities. In fact, some House Sparrow populations from Brazil showed lower haemosporidian prevalence compared to native birds and also to European populations (Lima et al. 2010; Marzal et al. 2011).

In Brazil, a study reported a 22.3% prevalence of *Toxoplasma gondii* from Eared Doves (*Zenaida auriculata*) sampled in areas with human influence (i.e., cropland, farm, university campus), and another study, also developed in Brazil, reported 25% infections in the House Sparrow for the same parasite (Gondim et al. 2010). Such results are relevant because high rates, as those reported above, may develop into human and veterinary health problems. *T. gondii* is highly prevalent in humans

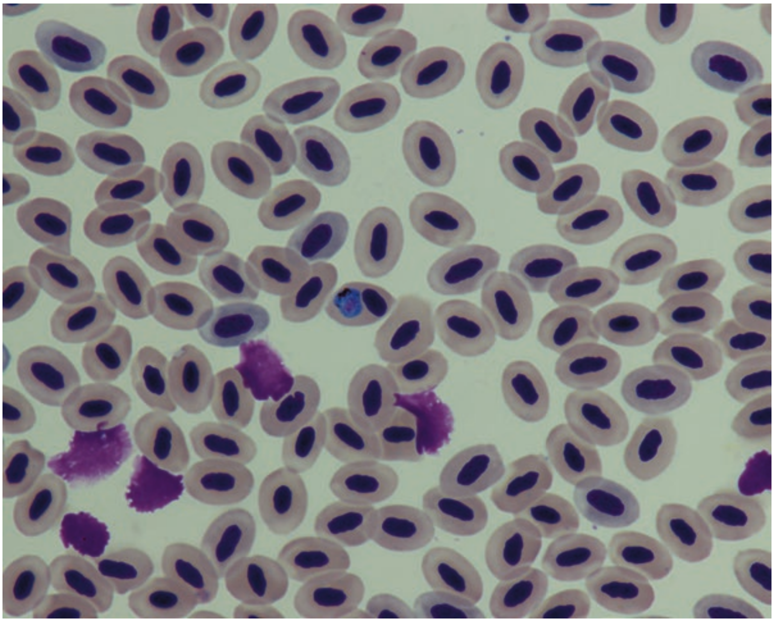

Fig. 7.3 A parasite of the genus *Plasmodium* subgenus *Haemamoeba* (a macrogametocyte), infecting a Chestnut-capped Brushfinch (*Arremon brunneinucha*) captured in an urban forest. The parasite is observed in the center, it displaces the nucleus of the erythrocyte towards the right side; all other surrounding erythrocytes are uninfected. Some immature erythrocytes are observed (i.e., those with a bluish-violet cytoplasm and an enlarged nucleus compared to mature erythrocytes) (Photo: DS-A)

around the world, but clinical cases (i.e., symptoms and disease) are less common (Roberts and Janovy 2009). In particular, *T. gondii* is a common parasite in domestic cats, which can be transmitted to humans and generate illness in pregnant woman (i.e., toxoplasmosis), producing birth defects, abortions, and even the death of fetuses (Roberts and Janovy 2009). Acute infections produce symptoms such as pain and swollen lymph nodes in the cervical and supraclavicular region, along with fever, headache, muscle pain, anemia, and sometimes lung problems (Roberts and Janovy 2009). In fact, a worrisome aspect in urban areas is that nonnative abundant bird species, such as doves and sparrows, can serve as reservoirs for parasites of health relevance (e.g., *T. gondii*, *Neospora caninum*; de Sousa et al. 2010, Gondim et al. 2010). Other parasites of veterinary importance detected in doves and pigeons sampled in Puerto Ayora (Galápagos) include *Trichomonas gallinae* with 44% prevalence (Padilla et al. 2004). *Salmonella* spp. have been detected infecting Rock Pigeons (8% prevalence) in São Paulo (Brazil), and in the same study, some pigeons were positive to serological tests against Newcastle disease virus (de Sousa et al. 2010). Similarly, a report from the state of Rio Grande do Sul (Brazil) has found prevalence rates ranging from 2.9 to 26.5% for different species of nematodes, infecting the Picui Ground-Dove (*Columbina picui*; Coimbra et al. 2009). Finally,

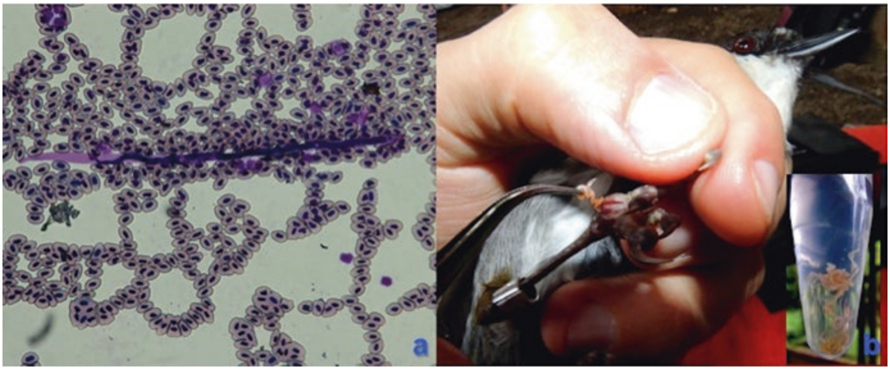

Fig. 7.4 A microfilaria or larva from a roundworm, surrounded by bird erythrocytes (**a**). Adult round worms of the genus *Pelecitus*, extracted from a foot nodule of a Chestnut-capped Brushfinch, a plastic tube shows all nematodes extracted from foot nodules (**b**) (Photos: DS-A)

infecting the Chestnut-capped Brushfinch, nematodes from the genus *Pelecitus* were found at both urban and peri-urban greenspaces in Xalapa (Mexico) (both larval stages in the blood and adult worms forming nodules on birds' legs; Santiago-Alarcon pers. obs.; Fig. 7.4).

In terms of viral diseases, which are sometimes of higher public concern due to their rapid adaptation to new hosts, researchers from Puerto Rico found that both native (Greater Antillean Grackle – *Quiscalus niger*) and nonnative (House Sparrow) urban exploiters were readily exposed to West Nile virus, particularly young birds of less than one-year-old (Komar et al. 2012). In Guatemala, this virus was isolated from sentinel domestic chickens at both urban and nonurban locations, but its main competent reservoir host was the Great-tailed Grackle (*Quiscalus mexicanus*). The authors of this study suggest that these grackles are the amplifying host in their study sites (Morales-Betoulle et al. 2013). Higher seroconversion (i.e., positive immunological tests, indicating exposure to the pathogen) of chickens was correlated with high temperature and low rainfall, both at urban and nonurban sites. The virus was also isolated from mosquitoes (i.e., *Culex quinquefasciatus*), which are considered a competent West Nile virus vector at other locations (Morales-Betoulle et al. 2013). Thus, current parasitological studies in Latin America suggest that native and nonnative birds using urban environments are susceptible to parasites with medical and veterinary importance.

Few studies have been focused on bird ectoparasites in urban Latin America. One interesting exception is a study in Mexico City, where cigarette butts found in nests of House Sparrows and House Finches (*Haemorhous mexicanus*) acted as an ectoparasite repellent (Suárez-Rodríguez et al. 2012). This study detected a reduction of nest-dwelling ectoparasites on nests built with cigarette butts. However, recent results show that this benefit could be counterbalanced by chemical damage on red blood cells of such birds more involved in nest building and incubation: an effect that is directly related to the amount of cigarette butts used in nest building.

In the case of House Finches, females were more involved in nesting and breeding activities, showing higher damage compared to males. Contrastingly, no difference in cell damage was detected between the sexes of House Sparrows, as both sexes are equally involved in breeding activities (Suárez-Rodríguez et al. 2017).

7.3 Knowledge Gaps and Future Directions

Taking into account all of the above, it is evident that there is a major lack of studies in urban Latin America focused on threats to birds. The few available studies are mainly from Brazil, Colombia, and Mexico, which are far from a good representation of the diversity of urban scenarios and surrounding environments across Latin America. This is worrisome because there is no current way in which we can measure the impact of such urban factors on Latin American bird communities and their emergent properties, which could be drivers of the general patterns identified for birds in the region (Ortega-Álvarez and MacGregor-Fors 2011; Chaps. 2, 3, 4, and 5). It is also clear that the major bird mortality source in cities is cat predation, either from feral or domestic cats (Loss et al. 2015). The other major sources of bird mortality in urban centers are buildings (particularly bird-window collisions), and collisions with vehicles and power lines. Finally, there is still a long way to know the effect of parasitism on bird health in the region, and we only glimpse at how ecological dynamics of host-parasite interactions are changing due to the urbanization process (e.g., Hernández-Lara et al. 2017). Hence, we propose the following research agenda focused on the major identified and potential threats to birds in urban Latin America.

7.3.1 Cat Predation

Systematic and informal information is needed to understand the nature and impacts of cat predation in urban Latin America; for example, questionnaires and data sheet reports, where cat owners can fill out the number of birds that their cats have retrieved and to have a historical estimate of cat predation based on owner memory. Also, placing cameras and trackers on cats in order to have more reliable measures of predation within and in the periphery of cities could widen our understanding of the hazard that cats represent for urban birds. This last procedure, in combination with systematic bird censuses through citizen science projects and intensive field searches, can be used to weigh estimates based on population densities of different bird species and guilds across time.

7.3.2 Bird Collisions with Urban Structures

As suggested above for cat predation, both systematic and informal approaches should be followed to maximize the amount of information. In particular, we suggest two steps to fill this gap: (i) conducting systematic surveys across cities periodically (e.g., monthly), taking into account factors such as road size, closeness to greenspaces, water sources, traffic rate, building height, number and dimension of windows, and density of power lines per square kilometer; (ii) once the main factors associated with this threat are identified, the use of cameras to continuously monitor such structures could aid in the improvement of collision estimates, as there are birds that strike but do not die from the impact. The suggested scheme could shed important light on how mortality varies seasonally and which are the most affected bird groups. One important thing to consider when estimating the effect of this type of threat is carcass decomposition and removal rates, as the information of dead birds will be lost in places where these rates are higher. Thus, knowing such rates will improve mortality estimates and avoid underestimations (see Hager et al. 2012; Bishop and Brogan 2013; Blancher 2013).

7.3.3 Parasitism

Performing systematic bird parasitism studies having urban and nonurban comparisons as a minimum for each study area, preferably including an urbanization intensity gradient. It is also important to conduct studies within cities because urban environments are highly heterogeneous. For instance, the density of hard relatively impervious structures might affect bird breeding biology, increasing bird density and the likelihood of disease transmission, also food provisioning via bird feeders can increase contact rates between healthy and diseased animals (Martin and Boruta 2014). Although we are starting to have a clearer idea of the ecology of parasites in Latin American urban systems (e.g., Medellín, Colombia; Mexico City and Xalapa, Mexico; Porto Alegre, Brazil), we are still far from knowing both the real impact on bird health and how host-parasite interactions are modified with urbanization. Certainly, the way in which bird diversity is modified by urbanization will have a direct impact on parasite ecological dynamics (e.g., dilution effect against amplification effect). Hence, answers to basic questions in order to manage veterinary and zoonotic threats are urgently needed, for instance: (i) which host species is a parasite of health importance infecting? (ii) how have parasite preferences changed from nonurban to urban settings? (iii) which hosts are super spreaders and which ones are dilution hosts?

7.3.4 Airports

Although not necessarily and directly related to urban threats, airplane strikes with birds are a relevant study topic. Although published studies are scarce in the region, reports from the USA show an increase in the number of strikes between 1990 (1851 strikes) and 2013 (11,399 strikes; Dolbeer 2015). Most importantly, there has been an increase in the number of documented species involved in aircraft strikes (Dolbeer 2015), which can certainly aid in the development of prevention plans. In a study conducted in Brazil (Parnaíba International Airport), several thousand bird individuals from different species have been recorded either directly landing on the runway or flying through landing or take-off routes (Oliveira Cardoso et al. 2014). It is important to consider that airports, even within large urban areas, often have vegetation and water sources that tend to concentrate wildlife species (Patricia Ramírez-Bastida pers. comm.). Bird mortality records from airports are present in unpublished technical reports throughout Latin America; thus, in addition to more studies, we urge airports and related governmental institutions to make the information regarding their bird strike studies available, so a better assessment of airports as bird threats can be conducted, as well as management plans can be developed.

7.3.5 Rodenticides

Rat poisons are typically nonspecific rodent control chemicals for rats and mice. Although they have been commonly used to control the Black Rat (*Rattus rattus*), Norway Rat (*Rattus norvegicus*), and House Mouse (*Mus musculus*), anticoagulant poisons are also toxic for other vertebrates. In Latin America, the effects of anticoagulants in wildlife have not been studied in detail, but some evidence suggests that nocturnal and diurnal raptors are a group of special vulnerability due to secondary and tertiary poison consuming via the food chain. In Colombian cities, for example, owls frequently prey on introduced rodents (Delgado-V et al. 2005), some of which have been tested positive for anticoagulants in at least two cities (i.e., Medellín and Bogota, Colombia). Hence, systematic toxicology studies are urgently needed in Latin American cities to know the magnitude of this threat and mitigate its ecological effects.

Once information related to the major threats for birds in urban Latin America becomes available, we will be able to develop evidence-based management and conservation strategies directed towards relevant factors reviewed in depth above. It is difficult to predict which factors will be the most relevant for different cities in Latin America, most likely they will not be the same, even when compared to better known regions (e.g., USA, Canada, Western Europe, and Australia). This is because each city is a unique system with a particular history and development. Although we expect that some general patterns will arise due to the urbanization process, such as avian parasite communities dominated by generalist species, higher infection rates at places with food provisioning (e.g., feeders), higher predation on bird species that inhabit and breed close to the ground, and increased collision rates for buildings that are taller and have a larger surface covered by reflecting windows, it is certainly premature to make generalizations at this stage.

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