Chapter 3
Who Is Who in the City? Bird Species Richness and Composition in Urban Latin America

Ian MacGregor-Fors and Michelle García-Arroyo

Abstract Urban ecology in Latin America still lags behind temperate developed countries; yet, knowledge in the region has increased remarkably in the last decade. Based on previously published literature, including major global and regional reviews, we underline the prominent patterns of bird species richness and composition recorded in urban Latin America, summarizing the main factors influencing such patterns and contrasting them with those found in other regions of the world. To obtain an updated set of publications focused on bird species richness and composition in Latin America, we performed a search in the Web of Science for literature published up to 2015. After filtering out publications not considering bird species richness and/or composition, a total of 464 remained. We classified the assessed publications in relation to the study area (region and country), publication year, general aims, and main findings. We found notable similarities and differences between patterns described in studies from across the globe and from those described in previous literature reviews focused on Latin American studies. Some of the most recent publications support previously identified patterns, providing a more comprehensive understanding of how birds are responding to urbanization and its associated processes. Finally, we highlight some areas of research opportunity that could broaden our comprehension of bird ecology in relation to urbanization in Latin America. In sum, we recommend further studies assessing bird species richness and composition in urban Latin America to consider more comprehensive and comparative approaches that account for the variability of conditions occurring within urban areas, including highly developed and depauperated sites at different geographical and temporal scales.

Keywords Biodiversity statistics • Bioindicators • Bird ecology • Urban matrix • Urbanization

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3.1 Introduction

The number of species present in a given area, their identity, and the distribution of their abundances have been used as fundamental ecological metrics for many decades (Jaccard 1912; MacArthur and MacArthur 1961; Gotelli and Colwell 2001; Magurran 2005). In this chapter, we focus on: (i) highlighting species richness and composition patterns that have been reported in urban areas across the globe during the past four decades; (ii) summarizing the main factors influencing these globally recognized patterns; (iii) conducting a comprehensive review of studies performed in urban areas of Latin America; (iv) contrasting these publications with those carried out in other regions of the world; and (v) highlighting areas of opportunity for future studies focusing on bird species richness and composition in Latin America. It is noteworthy that this chapter is devoted exclusively to patterns of species richness and composition (see Chap. 4 for information related to avian abundances and demographic dynamics in urban areas). For practicality, we used the 'community' concept to describe variations of avian species richness and composition in urban areas, following the simple and flexible definition provided by Fauth et al. (1996): "collection of species [in this case birds] occurring in the same space and time". We also considered publications that targeted focal bird species or groups (e.g., based on their phylogeny and/or use of resources) for our species composition assessments (namely 'assemblages', 'ensembles', and 'guilds'; sensu Fauth et al. 1996).

3.2 Global Species Richness and Composition Patterns

Previous literature reviews, starting with the keystone contributions of Marzluff et al. (2001), Chace and Walsh (2006), and Evans et al. (2009), have identified several general patterns describing bird species richness and composition in urban areas across the globe. It is noteworthy that each of these three leading literature reviews recognizes a clear underrepresentation of studies carried out in tropical urban settings, where biodiversity peaks but urbanization is expected to increase (Myers et al. 2000; United Nations 2015; see Chap. 1 for a detailed discussion). Fortunately, studies performed in tropical and subtropical cities have risen in recent years, showing a marked increase since 2003 (González-Urrutia 2009; Ortega-Álvarez and MacGregor-Fors 2011a; Chap. 2).

3.2.1 Species Richness

Previous literature reviews have found several patterns regarding the number of bird species that dwell in a given urban location, many of them with interesting exceptions. One of the most generalizable patterns is that urbanization tends to negatively

Fig. 3.1 Urban-dwelling birds using human-made structures in the city of Xalapa (Veracruz, Mexico). *Left*: Ferruginous Pygmy-Owl (*Glaucidium brasilianum*) perched on a tangle of electric and telephone wires. *Right*: Acorn Woodpeckers (*Melanerpes formicivorus*) perched and foraging at the top of a wooden telephone pole (Photos: Juan F. Escobar-Ibáñez)

affect bird species richness (Marzluff et al. 2001; Chace and Walsh 2006); yet, it has also been shown to peak at intermediate levels of urbanization (reviewed by Evans et al. 2009; also see Blair 1996; Lepczyk et al. 2008), rise with urbanization (Aldrich and Coffin 1980), and even show no differences between urban and nonurban sites (Sodhi 1992). These patterns are given by a diverse array of variables that can shape the results of studies addressing avian richness in urbanization gradients, as well as in urban–nonurban comparisons, of which temporality (Poague et al. 2000) and other social and economic predictors head the list (e.g., history, size, location, urbanization intensity, spatial heterogeneity; Edgar and Kershaw 1994; Germaine et al. 1998; Blair 2001).

As would be expected, urban vegetation heavily influences the number of bird species that can dwell within an urban area. In fact, most studies focused on urban bird species richness have concentrated their efforts within greenspaces (Chace and Walsh 2006; Evans et al. 2009; Malagamba-Rubio et al. 2013). Several greenspace characteristics have been identified to shape bird species richness in urban areas, showing two general patterns: (i) increases with vegetation complexity and diversity (Emlen 1974; Beissinger and Osborne 1982; Schwarzenberger and Dean 2003; Donnelly and Marzluff 2006; MacGregor-Fors 2008); and (ii) increases with patch size (Gavareski 1976; Mills et al. 1989; Chamberlain et al. 2007). 'Gray' urban infrastructure (DeGraff and Wentworth 1986; Sacchi et al. 2002) has also shown to determine bird abundances, essentially because some species are able to exploit urban conditions and resources (see Chaps. 4 and 5; Fig. 3.1). Other urban-related variables have been shown to correlate with bird species richness, including supplementary resources (e.g., nest boxes, bird feeders, urban litter; Gaston et al. 2005; Glue 2006; Fuller et al. 2008), human activity (e.g., passing pedestrians, vehicle traffic; Knight and Gutzwiller 1995; Miller et al. 1998), collisions (e.g., window, power-line, and car strikes; Klem 1989; Codoner 1995; Chap. 7), domestic and

urban-related predators (e.g., dogs, cats, corvids; Kristan et al. 2003; Jokimäki et al. 2005), competition with exotic/invasive bird species (MacGregor-Fors et al. 2010), and disease transmission (e.g., trichomoniasis; Boal and Mannan 1999).

3.2.2 Species Composition

Regarding the identity of birds in urban areas, several approaches have been used, including the assessment of changes in the species composition of communities, assemblages, ensembles, and guilds (sensu Fauth et al. 1996). A global literature review suggested that omnivore, granivore, and cavity-nesting species benefit from urbanization (Chace and Walsh 2006). However, a subsequent regional review, focused on urban birds from tropical and subtropical regions highlighted that, in addition to omnivores and granivores, other feeding guilds such as nectarivores, frugivores, and insectivores comprise an important proportion of the avifauna of cities in Australia, Singapore, and Mexico and Brazil, respectively (Ortega-Álvarez and MacGregor-Fors 2011a). Along with guilds and functional (often trophic) groups, other classifications have been used to assess the response of bird communities to urbanization. For example, studies have shown urbanization to have a greater negative effect on natives than exotics, as well as residents over migrants (Allen and O'Connor 2000; Poague et al. 2000), and specialists over generalists (Lancaster and Rees 1979; Johnston 2001; Fraterrigo and Wiens 2005; Smith and Wachob 2006).

3.2.3 Updated Global Literature Review

To thoroughly review and update the existing literature related to bird species richness and composition in urban areas around the globe, we used the Web of Science (http://webofknowledge.com) platform, which has recently broadened its databases to include additional journals, conference proceedings, book citation indices, and regional databases (e.g., SciELO, Russian Science Citation Index). We constrained our search for publications dating from 1900 to 2015, using the following databases: Web of Science Core Collection, Biological Abstracts, Current Contents Connect, Derwent Innovations Index, FSTA, KCI-Korean Journal Database, Russian Science Citation Index, SciELO Citation Index, and Zoological Record. To retrieve a broad initial sample of publications, we used the following keyword combination: ('urban' OR 'city') AND ('bird' OR 'avian') AND ('species richness' OR 'richness' OR 'composition' OR 'turnover' OR 'diversity'). We considered 'diversity' as a keyword for this chapter, as many researchers working with this topic base their studies within a diversity framework; however, we filtered publications that focused specifically on species richness and/or composition findings.

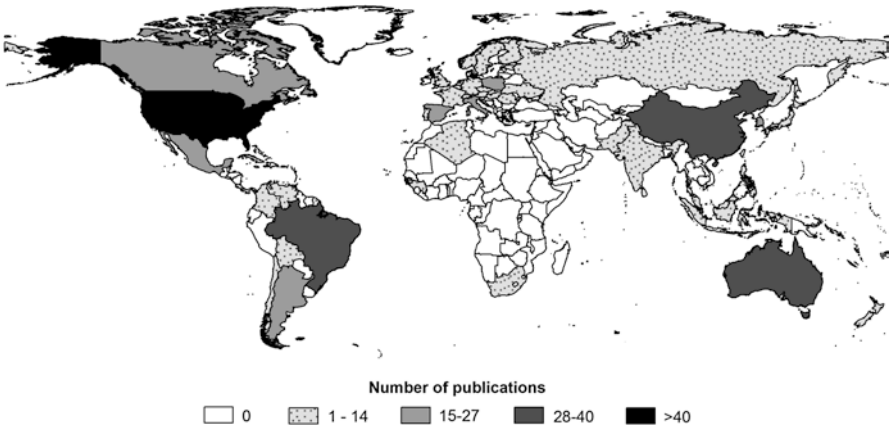

Fig. 3.2 Worldwide geographical representation of the number of reviewed publications by country

Our general search resulted in a total of 1434 publications, starting with studies from the late 1970s performed in Finland, North America, and Russia (e.g., Huhtalo and Järvinen 1977; Korolkova 1978; Lancaster and Rees 1979; Fig. 3.2). We performed a thorough screening of publication titles and abstracts to filter out those that fell outside of the scope of this chapter, which resulted in a total of 464 retrieved publications. We classified these publications by country, year of publication, general aims, and main findings (see Fig. 3.3 for a word cloud showing the most frequent words in the abstracts).

Our analysis of the 464 retrieved publications showed that most studies were carried out along urbanization gradients (which often, but not necessarily, include extra-urban systems; sensu MacGregor-Fors et al. 2010; Lancaster and Rees 1979; Rolando et al. 1997; van Rensburg et al. 2009; Verma and Murmu 2015), followed by those set up at specific urban locations (e.g., parks, gardens, preserves; Biaduń 1994; Day 1995; Donnelly and Marzluff 2004; Yang et al. 2015a), and considering urban versus nonurban comparisons (e.g., urban vs. 'rural', 'suburban', and/or 'natural' locations; Holtz 1998; Sorace 2001; Soh et al. 2006; Kopij 2011). It is noteworthy that some of these studies did not compare their results with adjacent systems (Luniak et al. 1986; Jones and Wieneke 2000; Dassanayaka and Mahaulpatha 2009; Strohbach et al. 2014). Among the most best-studied intra-urban conditions across the globe were: (i) parks (e.g., Tomiałojć 1998; Morneau et al. 1999; Densmore and French 2005; Zhang and Miao 2013); (ii) residential gardens (e.g., Catterall 2004; Chamberlain et al. 2004; Lerman et al. 2012; Paker et al. 2014); (iii) urban preserves (e.g., Mörtberg 2001; Drinnan 2005; Chapman and Reich 2007; Lin et al. 2013); (iv) wetlands (e.g., Rosa et al. 2003; Smith and Wachob 2006; Bensizerara et al. 2013; Sun et al. 2015); and (v) university campuses (e.g., Takeuchi et al. 2010; Shultz et al. 2012; Gatesire et al. 2014). Regarding studies that included nonurban systems, most comparisons of urban bird communities were made with those of native systems (e.g., woodland, shrubland, grassland; Yeoman and Nally 2005;

Fig. 3.3 Word cloud showing the most frequent words ($n = 250$; after eliminating articles, prepositions, conjunctions, interjections, and other common words) used in the abstracts of the 464 analyzed publications performed worldwide

Santos et al. 2008; Caula et al. 2010), followed by other human-modified systems (e.g., suburban, farmland, pastures; Parsons et al. 2003; Filippi-Codaccioni et al. 2009; Le Roux et al. 2015).

From our updated global review, we identified several general patterns regarding the species richness and composition of bird communities in urban areas that are consistent with those underlined in previous reviews of worldwide publications (Marzluff et al. 2001; Chace and Walsh 2006; Evans et al. 2009; Ortega-Álvarez and MacGregor-Fors 2011a): (i) bird species richness decreases with urbanization (e.g., Vallejo et al. 2009; Ciach 2012; Barth et al. 2015; Schneider et al. 2015); (ii) bird species richness increases with urban vegetation complexity and diversity (e.g., Melles et al. 2003; White et al. 2005; Husté et al. 2006; Kang et al. 2015), as well as with the age of the urban area (e.g., Jones 1981; Mason 1985; Fernández-Juricic 2000; Filippi-Codaccioni et al. 2008) and greenspace patch size (e.g., Fernández-Juricic 2000; Donnelly and Marzluff 2004; Palmer et al. 2008; Suk et al. 2014); (iii) species richness decreases with human activity (e.g., pedestrian and car traffic; Fernández-Juricic 2001; Platt and Lill 2006; Young et al. 2007; Verma and Murmu

2015); (iv) species identified to thrive in cities are commonly generalists (e.g., Conole and Kirkpatrick 2011; Davis and Wilcox 2013; Vignoli et al. 2013) and/or exotics (e.g., van Heezik et al. 2008; Loss et al. 2009; Gagné and Fahrig 2011; Luck et al. 2013), with omnivorous, granivorous, and insectivorous birds heading the list (i.e., omnivores: Clergeau et al. 1998; Smith 2003; Walker and Shochat 2010; Huang et al. 2015; granivores: Fox and Hockey 2007; Blair and Johnson 2008; Sengupta et al. 2014; insectivores: Zhou and Chu 2014; Kopij 2015).

Although some of these patterns have been considered in previous literature reviews (Marzluff et al. 2001; Chace and Walsh 2006; Evans et al. 2009; Ortega-Álvarez and MacGregor-Fors 2011a), the results of our updated global review identified some undermentioned new patterns, some of which are contradictory with generalized ones, such as: (i) bird species richness increases with urbanization across the globe (e.g., Pautasso and Dinetti 2009; Kopij 2011; Palita et al. 2011; Trammell et al. 2011); (ii) species richness increases with tree and shrub cover (e.g., Luther et al. 2008; Chong et al. 2014; Ikin et al. 2014; Yang et al. 2015b), native vegetation (e.g., Pennington et al. 2008; Burghardt et al. 2009; Davis and Wilcox 2013; Ikin et al. 2013), and the presence of water bodies (e.g., Melles et al. 2003; Smith 2003; Chamberlain et al. 2007; Shwartz et al. 2008); (iii) species richness decreases with building density (e.g., Maeda 1998; Palomino and Carrascal 2005; Caula et al. 2010; Schneider and Miller 2014), greenspace isolation (e.g., Murgui 2007; Lee et al. 2010; Smith and Chow-Fraser 2010; Shanahan et al. 2011), and percentage of impervious cover (e.g., Luck et al. 2013; Song 2015); and (iv) human commensal species are benefited by urbanization (e.g., Ciach 2012; Wood et al. 2015).

3.3 Species Richness and Composition in Urban Latin America

In 2011, Ortega-Álvarez and MacGregor-Fors (2011b; hereafter referred to as 'previous regional literature review') reviewed 84 studies published from 1974 to 2009 that focused on birds from urban Latin America. Studies assessing avian species richness and/or composition included comparative studies performed on setups involving urban–nonurban dichotomies (Fontana 2005; Tampson and Petry 2008), urban gradients (Reynaud and Thioulouse 2000; Leveau and Leveau 2004; Faggi and Perepelizin 2006; Faggi et al. 2006), intra-urban sites (e.g., residential areas: Argel-de-Oliveira 1995; Soares 2004; urban parks: Scherer et al. 2005; Gómez 2006; urban gardens: de Lima and Aleixo 2000; university campuses: MacGregor-Fors 2005; Marín-Gómez 2005), and nonurbanized systems within urban areas (e.g., beaches: Acosta-Ramos and Batista-Daudt 2005; da Silva 2006; lakes: Silva and Blamires 2007; secondary vegetation: Rivera-Gutiérrez 2006; da Silva 2006; urban forest remnants: Monnerat-Nogueira et al. 2005). In terms of the amount of information, previous comparisons have shown that research focused on bird

diversity in urban Latin America lags behind that of other regions, mainly those from temperate developed countries (Ortega-Álvarez and MacGregor-Fors 2011b; MacGregor-Fors and Ortega-Álvarez 2013; also see Chaps. 1 and 2).

3.4 Updated Literature Review of Urban Latin America

To review the existing knowledge of bird species richness and composition from Latin American urban settings, we used the filtered subset of 464 publications and grouped together all studies that were performed in any of the following 47 Latin American countries: Anguilla, Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, British Virgin Islands, Cayman Islands, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guadeloupe, Guatemala, Guiana, French Guiana, Haiti, Honduras, Jamaica, Martinique, Mexico, Montserrat, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Saint Barthélemy, Saint Kitts and Nevis, Saint Lucia, Saint Martin, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Turks and Caicos Islands, Uruguay, and Venezuela.

Of the 464 publications, 92 of them corresponded to studies that were both performed in Latin American urban areas and focused on urban bird species richness and composition, representing ~20% of the total retrieved publications (Fig. 3.4). This represents a noticeable increase in publications focused on urban bird species richness and composition in Latin America when compared with the previous regional literature review, with publications focused on these approaches from 2009 to 2015 (n = 50) representing a similar number of studied than those found to address ecological questions in the previous regional review.

When comparing the 92 reviewed publications from urban Latin America with those reviewed in the previous regional literature review, we found both similarities and differences, with the recent publications (2009–2015) strengthening the evidence for the patterns recognized across the world and shedding light on a more comprehensive understanding of the way in which birds respond to urbanization in Latin America. We identified several patterns that agree with those reported in the previous global and regional literature reviews: (i) species richness increases with vegetation structure and complexity (e.g., Cardozo et al. 2008; Carbó-Ramírez and Zuria 2011; Toledo et al. 2012; Leveau 2013; Domínguez-López and Ortega-Álvarez 2014), greenspace patch size (e.g., Garitano-Zavala and Gismondi 2003; Suarez-Rubio and Thomlinson 2009; dos Santos and Cademartori 2010; Carbó-Ramírez and Zuria 2011), and environmental heterogeneity (e.g., Manhães and Loures-Ribeiro 2005; Silva and Blamires 2007; Navarro et al. 2011; González-Oreja et al. 2012a, b); (ii) species richness decreases with human activity (e.g., pedestrians, vehicle traffic; Heil et al. 2007; Cruz and Piratelli 2011; MacGregor-Fors and Schondube 2011; González-Oreja et al. 2012a; MacGregor-Fors et al. 2012) and urban infrastructure (e.g., buildings, streets, squares; Carbó-Ramírez and Zuria 2011; MacGregor-Fors and Schondube 2011; MacGregor-Fors et al. 2012;

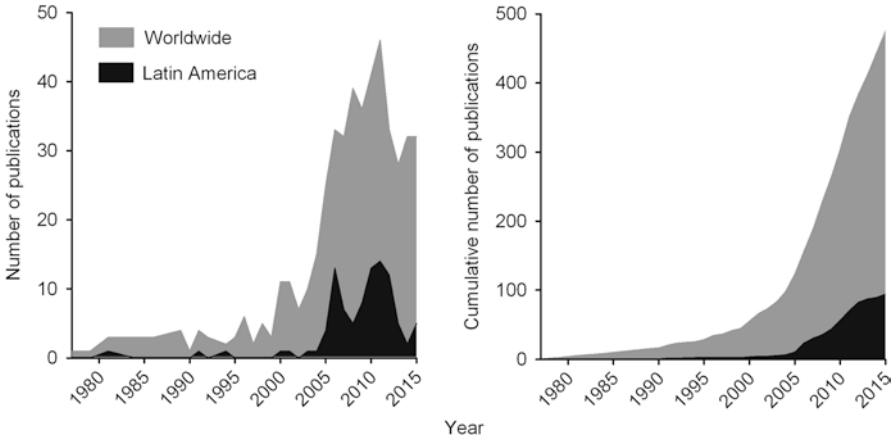

Fig. 3.4 Number of publications focused on avian species richness and composition in urban Latin America and across the globe through time

Sacco et al. 2015; Silva et al. 2015); and (iii) insectivorous birds are successful in urban areas (Germain et al. 2008; Fernández et al. 2009; Maragliano et al. 2009; Bispo and Scherer-Neto 2010; Brummelhaus et al. 2012), as well as generalist and exotic species (Garaffa et al. 2009; Ortega-Álvarez and MacGregor-Fors 2009; Presti and Echevarria 2009; Athiê and Dias 2010; Fontana et al. 2011). As pinpointed in the global literature reviews, recent studies developed in Latin America have been carried out in specific urban locations (e.g., parks, university campuses; Lopes and dos Anjos 2006; Muñoz et al. 2007; MacGregor-Fors and Ortega-Álvarez 2011; González-Oreja et al. 2012b; Charre et al. 2013), along urbanization gradients (Garaffa et al. 2009; Juri and Chani 2009; Villegas and Garitano-Zavala 2010; Leveau et al. 2015), and comparing urban versus nonurban sites (e.g., agriculture, native ecosystems; Rodríguez-Estrella 2007; Kennedy et al. 2010; Dario and De Vincenzo 2011; MacGregor-Fors et al. 2012; Domínguez-López and Ortega-Álvarez 2014). Multiple Latin American studies have also included water bodies and wetlands either within or near urban locations, underlining their importance as habitats for many bird species (Faggi et al. 2006; Silva and Blamires 2007; Molina et al. 2012; Rosselli and Stiles 2012). It is noteworthy that Latin American cities have been shown to shelter high avian diversity, mainly within their greenspace networks (Escobar-Ibáñez and MacGregor-Fors 2016). For instance, over 340 species have been recorded within the boundaries of the city of Xalapa, a small-sized Mexican city embedded within a cloud–forest matrix (González-García et al. 2014, 2016).

In addition to well-documented patterns of urban bird richness and composition in Latin America, we found interesting information that adds to our comprehension of how urbanization affects birds outside highly studied regions. For instance, we found that some recent studies in Latin America have started to consider a wider array of variables that may be acting as drivers of urban bird species richness values, such as assessing the origin of urban plant species (i.e., native/exotic). Results from

studies addressing the origin of plant species have found: (i) bird species richness increases with native plant species (Fernández et al. 2009); (ii) bird species richness decreases with exotic plant species (Silva et al. 2015); and (iii) bird richness peaks in combination of both native and exotic vegetation (Villegas and Garitano-Zavala 2010).

In contrast with composition patterns found in other regions across the globe, insectivorous and frugivorous bird species seem to be successful within urban areas in Latin America (Cruz and Piratelli 2011; Dario and De Vincenzo 2011; Blamires et al. 2012; Teles et al. 2012; de Oliveira and Blamires 2013). Nevertheless, there are publications that report a decrease in the presence and richness of insectivorous and frugivorous species in Latin American cities (Franz et al. 2010; Charre et al. 2013; Sanz and Caula 2015). Because feeding guilds present in urban areas partially reflect avian resource availability (Vogel et al. 2011), the discrepancy between insectivorous and frugivorous richness may be due to the highly variable environmental and structural heterogeneity for Latin American cities, as well as the species pool present in the surrounding systems. Altogether, species richness loss and composition shifts related to avian traits in urban systems (e.g., Suarez-Rubio and Thomlinson 2009; Franz et al. 2010; González-Oreja 2011) suggest an urban 'semi-permeability' process for birds (MacGregor-Fors 2010), although some urban 'avoider' species often remain within large urban greenspaces (Fig. 3.5), as suggested by Fischer et al. (2015).

3.5 Future Directions

Diversity measurements of bioindicator groups, such as birds, can improve our understanding of how wildlife species respond to human disturbances (Moreno et al. 2007). Yet, measuring some of the emergent properties of communities, as the ones addressed in this chapter (i.e., species richness, composition), can be technically challenging. As field and analytical procedures are continuously changing and evolving with our need to understand biodiversity, it is often complicated to contrast results between the wide array of metrics, which are often used indifferently. Thus, we suggest researchers to use up-to-date and robust methods to analyze their data, considering recommendations included by Magurran and McGill (2011) as well as more recent ones. For instance, when contrasting species richness among environmental conditions, we suggest the use of rarefied species richness values (Gotelli and Colwell 2001), extrapolated if needed, followed by the contrasting of confidence intervals to establish inferential results (MacGregor-Fors and Payton 2013). Regarding procedures to assess the composition of urban avian communities, it is crucial to appropriately select the level of analysis (e.g., community, assemblage, trophic groups), the approach to assess β–diversity (e.g., differentiation, scaling, turnover, nestedness), and the metric to quantify it (Koleff et al. 2003; Moreno and Rodríguez 2010; Baselga and Leprieur 2015).

Fig. 3.5 Colorful and/or charismatic birds that can be easily recorded in Latin American urban greenspaces. *Left*: Bananaquit (*Coereba flaveola*), Parque Natural Chico Mendes, Sorocaba, Brasil (Photo: IM-F). *Center*: Lineated Woodpecker (*Dryocopus lineatus*) Parque Fundadores, Armenia, Quindío. *Right*: Rufous-tailed Hummingbird (*Amazilia tzacatl*), Campus Universidad del Quindio, Armenia, Quindío (Photos: Oscar H. Marín Gómez)

As has been identified in the regional literature review, there is a clear underrepresentation of Latin American countries contributing to the urban bird knowledge. Additionally, research focuses in large and iconic cities (see Chap. 2), leaving aside the heterogeneity of urban scenarios and the associated response of their related avifaunas (see Chap. 9 for an in-depth analysis). Taking into account the information provided in previous regional literature reviews and our updated one, we identified some areas of opportunity that could aid in broadening the scope of potential factors that drive bird species richness and composition in urban Latin America.

The complex nature of urbanized landscapes raises an important need for researchers who are assessing urban bird species richness and composition to better incorporate contextual components and scale-dependent ecological variables into their studies (Rodríguez-Estrella 2007; Walker and Shochat 2010; Trammell et al. 2011; Lerman et al. 2012; Molina et al. 2012). As noted previously, many studies developed in urban Latin America have focused their surveys on single and specific types of sites, such as greenspaces, with little information regarding the context in which study areas are embedded. In this sense, we have identified three important considerations for establishing such a context. First, most studies ignore the urban matrix that surrounds target urban greenspaces. If we aim to understand how urban systems work and how they relate to biodiversity, it is crucial to assess highly urbanized systems to get a broader ecological picture (Fuller et al. 2009; Nilon et al. 2011; Sushinsky et al. 2013; Escobar-Ibáñez and MacGregor-Fors 2016). Thus, we suggest researchers to follow comparative approaches, such as using highly developed versus lowly developed urban sites, urbanization intensity gradients (McDonnell and Pickett 1990; Hahs and McDonnell 2006; Ortega-Álvarez and MacGregor-Fors 2009; Leveau et al. 2015; Silva et al. 2015), and citywide surveys that include

representative samples of the physical, environmental, and socioeconomic variances that occur within cities (Turner 2003).

Second, broadening the geographical scale of studies could provide, in general, the context of the landscape of which any given city is a part of (La Sorte et al. 2014; Lee and Carroll 2014; Tryjanowski et al. 2015). Depending on the level of analysis and scope, this could also add to our knowledge on more regional patterns that better reflect the variability of urban conditions and scenarios, as has recently been accomplished at a global scale (Aronson et al. 2014; Sol et al. 2014). Although intensive studies of focal cities are of major importance, comparative studies at different scales will undoubtedly broaden our comprehension of the ways in which avian communities are responding and adapting to urbanization in Latin America (Chap. 6). Another aspect to consider is the temporal scale. The time span of most ecological bird studies in urban areas is relatively short (Marzluff et al. 2001), which also applies to those performed in Latin America (pers. obs.). While short-term studies are helpful in many circumstances (MacGregor-Fors et al. 2015), mid-term and long-term studies are essential to understand the temporal dynamics related to the responses of bird communities to urbanization (Ormond et al. 2014; Strohbach et al. 2014; Escobar-Ibáñez and MacGregor-Fors 2016). For instance, temporal analyses of avian communities can provide information on the differential use of resources, which in fact can drive both urban bird species richness and composition (Catterall et al. 2010; Shultz et al. 2012; see Chaps. 5 and 6).

Third, there has been growing interest toward studying how biodiversity responds to land-use change at the urban fringe, where cities tend to sprawl. Given that urbanization implies the modification or replacement of preexisting systems, including changes in the terrain, hydrology, and vegetation, among other components, their boundaries can act as filters for wildlife species (Croci et al. 2008). The area where the urban core (intra-urban area) merges with adjacent systems, namely the 'ecotones' in which urban areas interact with immediate nonurban systems (peri-urban areas), have been proven to be ecologically relevant for bird communities, with richer communities found in peri-urban areas when compared with intra-urban sites with similar traits (MacGregor-Fors 2010; Puga-Caballero et al. 2014). These kinds of studies focused on bird species richness and composition are quite scarce in the overall literature, but there is a good representation of Latin American cities among them (Garaffa et al. 2009; MacGregor-Fors 2010; Puga-Caballero et al. 2014). Although some studies have begun to focus on the conceptual framework of 'peri-urban' areas (e.g., Iaquinta and Drescher 2000; Tjallingii 2000; Snep et al. 2006), this topic is incipient and could provide an important ecological foundation for developing and implementing practices that address issues presented by urban sprawl.

Finally, there is a topic that requires special attention to understand how urbanization can shape regional avifaunas. Previous studies performed across the globe have suggested that biotic homogenization takes place in urban areas (McKinney 2006; Devictor et al. 2007; Ortega-Álvarez and MacGregor-Fors 2009; Murthy et al. 2016); yet, recent global-scale studies show contrastingly different results

regarding this phenomenon. On the one hand, Aronson et al. (2014) showed that, using an incidence-based worldwide urban bird dataset considering 54 urban areas, cities retain similar composition patterns within biogeographical realms, suggesting that urban avifaunas have not been taxonomically homogenized at the global scale. On the other hand, Sol et al. (2014), using an abundance-based dataset of 22 cities, show that species are being filtered by urbanization due to their lack of capability in adapting to the novel conditions, mainly related to the use and exploitation of urban resources and avoidance of urban-related risks (see Chap. 7), reducing β-diversity, and ultimately promoting biotic homogenization. Thus, there is still a dearth of knowledge on the scales and factors related to potential homogenization of biota driven by urbanization, making this a highly important topic to tackle. However, researchers need to be careful when assessing biotic homogenization, as some fundamental concepts are prone to being misconstrued (Olden 2006; see Chap. 9). Lastly, we strongly encourage that all studies, regardless of their aims, scopes, and/or scales should devote a section that provides feasible urban management and planning strategies founded on their evidence-based findings.

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