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Research Paper

The effect of plant richness and urban garden structure on bird species richness, diversity and community structure

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HIGHLIGHTS

- Bird species diversity is positively related to shrubs species richness.
- Richness of trees and shrubs, small lawns and tree cover invite most bird species.
- Native birds prefer to forage on native trees, while alien birds – on alien trees.
- Bird species diversity changes with migrating seasons.
- Presence of people and dogs has a negative effect on birds' presence.

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ABSTRACT

Urban green areas improve the standard of living in cities and affect people's attitude to nature and conservation. Zoological knowledge may provide data that will help designers to enhance bird diversity in gardens. We studied the effect of plant species richness and structure on bird species richness, diversity and community structure in 25 public gardens in Tel-Aviv city and, neighboring suburbs, Israel. A total of 65 bird species were observed, of which nine were urban, exploiters or alien species. These latter species composed 54% of all individuals seen. Additional 13 bird species, mostly migrants, were observed in gardens further from the observation fixed radius. We found that shrubs species richness positively affected bird species diversity. Most bird species were found where trees and shrubs species richness was high, and trees and lawn cover were medium or low. High trees or high lawn cover attracted only a few bird species, mostly aliens and urban exploiters. Native birds preferred to forage on native trees and alien birds preferred to feed on alien trees. Bird species diversity was higher during spring and fall because of the presence of migrating bird species. Dogs and people had a negative effect on bird presence. Accordingly, we recommend that when planning new gardens, designers will avoid large lawns, prefer diverse and dense shrubberies, native trees, and will create some areas that will not be accessible to dogs and people. Finally, we emphasize the importance of multidisciplinary studies conducted in collaboration between landscape designers and zoologists.

1. Introduction

Currently, almost half the world's human population lives in cities and by 2030 the proportion living in cities is expected to reach 60% (United Nations, 2004). Urban population growth causes natural habitat loss by conversion of natural habitats into urbanized areas (McKinney, 2002), resulting in biodiversity homogenization (Blair, 1996) and decreased native biodiversity (Bino et al., 2008; Blair, 1999; Czech, Krausman, & Devers, 2000; Kendle & Forbes, 1997; Mason, Moorman, Hess, & Sinclair, 2007). Because urbanization and its consequences occur worldwide, there is an agreement that the ecological outcome could be staggering, and therefore it is essential to monitor patterns and trends in urban areas. For example, Puth and Burns (2009) used species richness, a widespread ecological metric, to assess the status and changes in biological diversity of flora and fauna in the New York metropolitan area over time. They argue that using such quantitative metrics is advantageous, as they can serve as indicators for trends in productivity, invasibility, extinction, and stability. Nevertheless, in a recent review, Magle, Vernon, and Crooks (2012) show that although

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urbanization impacts on wildlife, trends in urban wildlife studies have not been evaluated systematically, and nearly all were conducted in North America, Europe, or Australia.

Urban nature, found in parks and smaller urban green areas (such as public and private gardens), improves the standard of living in cities (Miller, 2005) and can affect people's attitude to natural ecosystems and conservation (Savard, Clergeau, & Mennechez, 2000; Tilghman, 1987). Thus, the quality of urban environments, and particularly of urban green spaces, is increasingly regarded as an important issue (Gaston et al., 2007). These green spaces that are set aside for recreational use include parks (which are relatively large and can be in their natural or semi-natural state), or gardens (which are smaller and planned-spaces). In assessing the quality of urban gardens, birds became a subject for considerable research (Sandstrom, Angelstam, & Mikusinski, 2006) for several reasons: most birds are diurnal, conspicuous and can be identified and observed with relative ease and hence their spatial variation can be well recorded (Bino et al., 2008). In addition to this practical reason, in comparison with other taxa (e.g. invertebrates, reptiles, amphibians), birds are probably the one taxon that people are most familiar with, and can identify to a certain extent. Moreover, birds are the taxon that people most actively attempt to engage with, for example by providing them with feeders or nesting boxes (reviewed by Baker, Thomas, Newson, Thomson, & Paling, 2010). In England, for example, as a consequence, the status of bird populations is utilized by the government as a 'quality of life' metric for urban occupants (Dept. of Environment, Food and Rural Affairs [Defra], 2003).

Bird communities can be evaluated in several ways: (1) Bird species richness, which is the number of bird species found in one habitat. (2) Bird species diversity, which can be calculated by using indices such as Shannon index that takes into account both the number of species present and their relative abundance in the community (Magurran, 1988). (3) Bird community structure, which is typified by an assemblage of several species that are associated with a certain habitat and tend to appear together in this habitat. For example, a recent study in England identified three breeding bird communities in Bristol: a rural community (associated with woodland, managed grassland and inland water), suburban community (associated with buildings and residential gardens), and intermediate community (that shared some of these habitats characteristics) (Baker et al., 2010). By characterizing bird communities we can increase our understanding of the interactions between birds and various urban habitats they use. Also, we can provide further insights on the effects that environmental variables have on different bird species, an improvement over calculating only species richness and diversity. Such environmental variables, which might affect fitness of birds, may include physical habitat diversity, for example – structures that resemble cliffs (high rising buildings), structures that provide nesting sites that are naturally limited (i.e. holes) in illumination poles and traffic lights, exotic vegetation with new feeding and nesting opportunities, etc.

Several urban factors are known to affect these indices. For example, in a review article, Goddard, Dougill, and Benton (2010) discuss mechanisms for encouraging 'wildlife-friendly' management of collections of gardens across scales from the neighborhood to the city, and one of their assumptions is that garden size positively affects species richness. They based this assumption on previous studies (e.g. Daniels & Kirkpatrick, 2006) that found that bird species richness in Australia was positively related to garden size within the range of 50–1600 m^2. Garden location in relation to city center also affects bird species richness and total abundance: bird species richness decreases from natural or rural areas to city centers (Bino et al., 2008) while bird total abundance increases (Blair, 1999). Urbanization level around gardens or parks affects bird species composition: in sites that are surrounded by similar urbanization levels bird species composition is similar. Level of urbanization in the surrounding area can be more important than site size and plant structure in determining bird community composition (Huste & Boulinier, 2011). Urban environments can cause an increase of total bird richness and abundance. For example, in Britain it was found that these two indices increased over a wide range of household densities and then declined at greater household densities (Taratalos et al., 2007). However, the decline occurred at house densities below the one required in new developments, indicating the difficulty in maintaining a balance between biodiversity conservation and urban planning. Birds are also sensitive to landscape composition and configuration (Pellissier, Cohenb, Boulayb, & Clergeau, 2012).

The level of urbanization may have a differential effect on indigenous, migrant and invading species. On one hand, in countries with medium to high precipitation, low urbanization level may be synonymous with high plant density, thus "inviting" indigenous birds and arboreal migrants. Indigenous birds may also be attracted to native vegetation that grows spontaneously in such areas. On the other hand, high urbanization level may be accompanied by more opportunities for invading species that are attracted to garbage. It may also provide more opportunities to invading urban exploiters that prefer to nest in holes (i.e. the Indian mynah *Acridotheres tristis* and the Rose-ringed Parakeet *Psittacula krameri*) or on ledges in buildings (i.e. laughing dove *Streptopelia senegalensis*) that in Israel are abundant in areas of high urbanization level.

Studies that report a positive relation between bird richness and urban environment explain this outcome by the presence of urban exploiters and alien bird species that thrive in urban areas (Chace & Walsh, 2006), and a recent review (Lowry, Lill, & Wong, 2013) points out that species that have greater behavioral flexibility to the new selection pressures presented by cities should have greater success in urban habitats. Other studies characterize species that favor urban development as generalist, which feed on plant material and nest above the ground (Evans, Chamberlain, Hatchwell, Gregory, & Gaston, 2011). Similarly in Israel, Kark, Iwaniuk, Schalimtzek, and Banker (2007) found that being successful in more urbanized environments depends on a combination of traits, including diet, sociality, sedentariness and preferred nesting sites. They report that ground nesters are rarely seen in dense city areas, because humans or domesticated animals threaten them. However, nesting above the ground is also not always successful in urban areas, and experimental studies in Finland indicate that predation affected birds in the city, and nest predation was higher in the town center than in the less urbanized area of detached houses (Huhta, Jokimäki, & Rahko, 1999; Jokimaki & Huhta, 2000). Most of the nests in the town center were destroyed by avian predators.

Plant composition in urban gardens is another important factor that affects birds' communities: High coverage of shrubs and tall trees were found to be important for native forest birds in Tasmania (Daniels & Kirkpatrick, 2006). Adult trees and heterogenic plants layers were positively correlated with high bird diversity in urban open areas in the U.S.A (Mason et al., 2007) and Sweden (Mortberg & Wallentinus, 2000). Tree cover was found to be important also for species richness and bird abundance of migrating birds in Mexico (MacGregor-Fors, Morales-Perez, & Schondube, 2010). In summary, several factors have been found to affect bird presence and bird community composition in gardens. The most important of them are plant composition in gardens, the proportion of tree and shrub cover, garden size, the degree of urbanization, and predation risk. However, the effect of plant composition and garden spatial structure on bird communities might not be the same in different parts of the world. In Israel, this question has not been yet investigated in depth, and the only study that refers to this issue found that high lawn coverage negatively affected bird species richness