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Woody trees, green space and park size improve avian biodiversity in urban landscapes of Peninsular Malaysia

Nurul Aida[a], Selvadurai Sasidhran[a], Norizah Kamarudin[a], Najjib Aziz[b], Chong Leong Puan[a], Badrul Azhar[a,c,*]

[a] Faculty of Forestry, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[b] School of Land and Food, University of Tasmania, Tasmania 7001, Australia
[c] Biodiversity Unit, Institute of Bioscience, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

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ABSTRACT

Rapid urbanization in major cities has adversely affected avian biodiversity in both developed and developing countries. Due to over-urbanization and little regard for nature conservation, such cities are usually characterized by poor biodiversity. In contrast to central business district areas, suburbs may support greater levels of biodiversity through an increase in green areas. We examined urban bird species richness, abundance, and composition in Klang Valley, Peninsular Malaysia. We surveyed 141 points for passerines across 80 parks grouped into two different urban zones, namely central business districts and suburbs. Our results revealed that bird richness did not differ significantly ($p = 0.994$) between central business districts and the suburbs. We found that the abundances of birds were significantly greater in the suburbs than in central business districts. However, species composition was similar between the central business districts and suburbs. We also found that bird richness increased significantly with an increase in size of green areas and park areas, as well as the number of woody trees in both zones. Evidence from this study suggests that creating urban parks and gardens, coupled with tree planting in central business districts, is able to support greater biodiversity, at least for birds in cities similar to those found in the suburbs.

1. Introduction

Urban landscapes are expanding rapidly with the increase in the human population (Faeth et al., 2005; Lerman and Warren, 2011; Marzluff et al., 2001; Shochat et al., 2006), in most cases at the expense of flora and fauna species richness (Marzluff and Ewing, 2001; Melles et al., 2003; Sandstrom et al., 2006). Many cities lack green spaces due to trade-offs for the development of housing estates, commercial buildings, and paved roads. Green areas such as urban parks and gardens, if present, are designed to mitigate environmental pollutions, beautify cities, and boost urban biodiversity (Goddard et al., 2010).

Urbanization may impact wildlife through the loss and degradation of habitats, by eliminating or changing natural habitats, which is widely recognized as a major threat to biodiversity (Clergeau et al., 1998). Due to habitat modification, many species are unable to adapt to urban environments. Thus, biodiversity is generally low in these urban areas (Crooks et al., 2004; McKinney, 2006). For instance, loss of avian biodiversity has been linked to urbanization (Cam et al., 2000; Manhães and Loures-Ribeiro, 2005). Previous studies have demonstrated that the densities of some common birds of suburbs, as well as ground nesting birds, were significantly lower in urban areas (e.g. central business district) (Beissinger and Osborne, 1982).

Urbanization can benefit avian biodiversity, although this may be limited to a small number of species of open-area birds and those that are pollution tolerant (Clergeau et al., 2001). Only certain species can adapt and survive in urban environments, which are often lower in numbers than normal populations found in their native habitats (McKinney, 2002). Species commonly found in urban areas (e.g. those in Singapore and Manila) include the Rock Pigeon (*Columba livia*), Common Starling (*Sturnus vulgaris*) and house sparrow (*Passer domesticus*) (McKinney, 2006; Robinson et al., 2005). These species may have the ability to live and forage at bird feeders or exploit human-related resources (e.g. dump sites and garbage) (Chace and Walsh, 2006). They also build their

* Corresponding author at: Universiti Putra Malaysia, Institute of Bioscience, Serdang 43400, Malaysia.
E-mail addresses: badrulazhar@yahoo.com, b_azhar@upm.edu.my (B. Azhar).

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nests in closer proximity to humans (Donnelly and Marzluff, 2006; Jokimaki, 1999).

Absence of a natural environment in urban areas may lead to species homogenization (Blair, 2001a,b; Clergeau et al., 2006). For example, urbanization appears a cause of taxonomic homogenization of the avifauna in towns of three temperate countries: Italy, France, and Finland (Clergeau et al., 2006). Similarly, biotic homogenization was reported in tropical cities such as Manila and Hong Kong (Vallejo et al., 2009; Zhou et al., 2012). This is due to urban parks, which are simplified ecosystems that no longer exhibit the characteristics of natural habitats such as forests. Most studies related to urban biodiversity have reported an increase in avian population density but a decrease in species diversity as urbanization increases (Beissinger and Osborne, 1982; Marzluff, 2001).

In the suburbs, bird diversity is usually higher than what is found in urban centers and sometimes even higher than in non-urban regions, natural habitats, or those with minimal urban pollutions (Blair, 1996, 1999; Clergeau et al., 1998; Jokimaki and Suhonen, 1993). This paradox of higher diversity and abundance of birds in suburbs is due to the fact that they can provide habitat for both native and introduced species (Blair, 1996). In contrast with suburban areas, urban areas are unlikely to be rich with key resources (e.g. food and cover) which significantly affect biodiversity, especially birds (McKinney, 2002; Savard et al., 2000). To improve biodiversity in the urban landscape, parks and gardens are typically developed in both suburbs and central business districts. Urban parks or gardens that constitute a variety of habitats including plant species are able to maintain higher levels of native biodiversity (Fernández-Juricic, 2004). Urban parks with additional components such as a variety of plant species and water sources can also maintain higher levels of avian biodiversity (Shwartz et al., 2008).

In Southeast Asia, rapid growth in the economy has increased the expansion of concrete buildings as well as human activities (i.e. work and business) and cities have become more strongly human-modified environments (Grimm et al., 2008; Restrepo and Halffter, 2013). Urban development might affect the distribution of birds. In tropical cities such as Manila, green space areas correlate positively with bird richness and abundance as well as preserved avian biodiversity, whereas urbanization tends to result in decreased biodiversity (Benjamin et al., 2007). This can also be observed in Singapore, where urbanization negatively affects richness and abundance of nesting sites and has resulted in declined avian biodiversity (Lim and Sodhi, 2004). Ecological studies of urban birds always result in decreasing species richness with increasing urbanization (Melles et al., 2003; Sandstrom et al., 2006). However, biodiversity conservation within towns and cities, particularly urban parks and gardens, plays a significant role in minimizing both the extinction of species and the extinction of the human experience of wildlife (Goddard et al., 2010).

To monitor biodiversity in human-modified landscapes such as towns and cities, birds may be used as an ecological indicator (Croonquist and Brooks, 1991; Gregory et al., 2005; Padoa-Schioppa et al., 2006). There is so much information about birds, their biology and life history are well understood. This is the main advantage of using birds as an ecological indicator. Birds are relatively sensitive to changes in habitat structure and composition and are therefore useful indicators of changes and stresses in the urban ecosystem (Blair, 1999). The response of birds to ecological change can enhance our understanding of the long term impact of urbanization on the terrestrial ecosystem (Bibby, 2000).

This study investigated how urban birds respond to urban environments and development in Malaysia. The study was carried out in central business district and suburbs consisting of green urban areas, including recreational parks and gardens. First, we examined patterns of avian biodiversity in Klang Valley, which is the main commercial center of Malaysia. Specifically, we quantified urban bird species richness, abundance, and composition according to different management zones i.e. central business districts and suburbs. Suburbs or urban outskirts were predicted to have the potential to support greater species richness and abundance as well as more diverse communities of birds compared to central business districts. Secondly, we examined the relationship between bird richness and habitat quality at local and landscape levels. Thirdly, we determined environmental attributes influencing urban bird species composition.

2. Methods

2.1. Study area

This study was conducted at 80 urban parks in Klang Valley area, covering 284,300 ha of urban landscape in central Selangor state, Malaysia (Fig. 1). Klang Valley comprises Kuala Lumpur and its suburbs, Shah Alam, Petaling Jaya, Subang Jaya, Puchong, Klang, Pelabuhan Klang, Ampang, Gombak, and Cheras, which are satellite towns. Klang Valley has approximately six million residents (Department of Statistics, Malaysia, 2014). Temperatures in the area generally range between 29 °C–35 °C during the day and 26 °C–29 °C at night (Malaysian Meteorological Services Department, 2014).

Our study area was divided into two different urban zones, namely central business districts and suburbs. We defined central business districts as the busiest zone designated for commercial activities. Central business districts are characterized by a concentration of retail and office buildings. Suburbs were defined as residential areas with fewer commercial activities than a city or town. Suburbs are usually located on the outskirts of the city, with more green space imitating a forest-like environment. Parks or gardens, openly accessible to the general public in both central business districts and suburbs, are managed by the local authorities. Most parks or gardens have a variety of native plant species.

2.2. Bird sampling and study design

We used systematic sampling with random starting points (Morrison et al., 2008). Eighty parks were sampled using the point count method. The coordinates and altitudes of selected points were determined via handheld GPS. A total of 40 sites were selected within central business districts and suburban areas, respectively. Each study site was spaced at least three kilometers apart from other parks. The number of sampling points was scaled relative to area (Mean ± SE = 1.763 ± 0.130 sampling points per site). A total of 101 sampling points with 50 m radius were established in central business districts. In suburbs, a total of 40 sampling points were established. Sampling points were set up 200 m apart to minimize double counts.

Bird sightings or vocalizations were recorded. We identified and counted birds within ten minutes at each point. Birds flying through a point count area (e.g. not using the site) were excluded from the survey to avoid pseudo counts (Lepczyk and Warren, 2012). Study sites were visited in the morning during weekdays when human activities peaked and the birds were most active. Surveys ran from 7.00 a.m. until 11.00 a.m. and were conducted three times at each site. Surveys were not conducted during rainy days or days with high winds. Migratory species were excluded from the survey. We conducted bird sampling from February to July 2014, outside of monsoon season (October-January).

2.3. Measurements of local-level and landscape-level attributes

Eight local-level attributes were measured or estimated at each sampling point. Measurements or estimations were taken at each