Pertanika J. Sci. & Technol. 31 (2): 1035 - 1046 (2023)

PERTANIKA JOURNALS

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Distribution of Six Urban Bird Species in Urban Agglomeration of Central Region of Peninsular Malaysia Using Ebird Database

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ABSTRACT

Developing countries are undergoing rapid urbanisation to fulfil the high demands of incremental population growth, construction, and development. Excessive development has negative impacts on biodiversity by altering or destroying habitats. However, each bird species may respond differently to habitat alteration. Therefore, this study was conducted to determine the distribution of urban bird species in metropolitan cities and nearby areas in Peninsular Malaysia. The main objective of this study was to determine the distribution patterns of six aesthetically valuable urban bird species (Black-naped Oriole [*Oriolus chinensis*], Yellow-vented Bulbul [*Pycnonotus goiavier*], White-throated Kingfisher [*Halcyon smyrnensis*], Pink-necked Green-Pigeon [*Treron vernans*], Coppersmith Barbet [*Psilopogon haemacephalus*] and Common Iora [*Aegithina tiphia*]) in Greater Kuala Lumpur (the Klang Valley region) using observations from a citizen science (eBird) database. We mapped species abundance throughout the focal area using ArcGIS and analysed the data using Minitab. Three urban bird species dominated, with the highest number of observations recorded: Yellow-vented Bulbul (46.59%), Pink-necked Green-Pigeon (19.25%), and Black-naped Oriole (13.00%). While, the Coppersmith Barbet had the lowest recorded observations (2.76%). Species abundance differed significantly across the study region (F=5.12, p<0.05), with the studied species' occurrence increasing as green spaces increased. Such dynamic mapping is crucial for better understanding the mechanisms of the persistence of urban biodiversity. We suggest creating more green areas and planting roadside trees to provide green corridors within cities to help sustain urban biodiversity.

Keywords: Citizen science data, distribution, green space, Malaysia, metropolitan city, urban birds

ARTICLE INFO

Article history:
Received: 03 April 2022
Accepted: 10 June 2022
Published: 20 March 2023

DOI: https://doi.org/10.47836/pjst.31.2.20

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ISSN: 0128-7680
e-ISSN: 2231-8526

INTRODUCTION

Urban populations in developing countries increased from 286 million in 1950 to 2,251 million in 2000 (Yaakob et al., 2010), and 79.7% of the world's population lives in developing countries in Southeast Asia, such as Malaysia (United Nations, 2019). Urbanisation is a multidimensional process that is influenced by rapid transformations in the human population in an area, where land-use changes and population transitions can cause a complex habitat mosaic and have significant impacts to varying degrees on the environment (Brush, 2016). For example, rapid forest exploitation during urbanisation transforms green areas into residential, commercial, and recreational areas.

Urbanisation and sub-urbanisation, which have become the latest universal trends in the rapid development phase, have negative impacts, either directly or indirectly, on the environment and the ecological dimension of sustainable development (Sandström et al., 2006). Increased levels of urbanisation can result in the decline in arthropods, amphibians, mammals, reptiles and birds due to habitat loss. On the other hand, the reduction in the quality of the remaining habitats due to the replacement of green areas by built-up areas exacerbates the effects of disturbance on animals (Marzluff & Ewing, 2001; McKinney, 2008). Approximately 60% of bird studies considering species richness generally show declining richness with increasing urbanisation (Chace & Walsh, 2006; Marzluff, 2001).

However, urbanisation can also benefit avian biodiversity due to the ability of certain species to adapt to cities. Not all species are potentially susceptible to urbanisation-induced fragmentation (Callaghan et al., 2019; Kark et al., 2007). In general, bird species may show different responses to urbanisation which can be influenced by both intrinsic and extrinsic landscape elements in the urban environment (Callaghan et al., 2018). In addition, some species may have special traits that allow them to adapt to uncertain environments, potentially resulting in ecological inheritance through trait distributions filtered by the environment (Odling-Smee et al., 2013; Webb et al., 2010).

Birds are the ideal subjects to study the effects of habitat fragmentation and landscape change as they are easily identified, clearly visible and sensitive to land-use changes (Hensley, 2018; Mansor et al., 2011; Nasruddin-Roshidi et al., 2021). Birds are also often clearly visible to the public in the city, and their presence is highly anticipated by most visitors to urban parks (Jasmani et al., 2017). Moreover, birds are ecologically highly diverse and show different responses to urbanisation according to the specific ecological traits of each species (Sol et al., 2013). Likewise, an avian group's life history and ecological characteristics are more competent than other vertebrate groups.

Urban birds tend to be common species, most of which are found near human settlements since they can tolerate human disturbance due to their ability to adapt and survive and reproduce (Idilfitri & Mohamad, 2012). Urban birds could find alternatives to nesting sites and search for food within human-occupied areas. Urbanisation favours common species of avian omnivores, insectivores, granivores and frugivores. Bird communities

can be categorised into three groups along an increasing urbanisation gradient: 'urban avoiders' living outside the city; 'suburban adapters' that live in areas with a moderate level of urbanisation; and 'urban exploiters' that live surrounded by buildings and roads in the most developed areas (Blair, 1996).

Citizen science data can be used to collect large amounts of bird occurrence data in a number of habitats and locations over the long term (Callaghan & Gawlik, 2015). In this study, we used citizen science data from the online database eBird (https://ebird.org/home) to examine the distribution of six aesthetically pleasing urban bird species: Pink-necked Green-Pigeon (*Treron vernans*), White-throated Kingfisher (*Halcyon smyrnensis*), Coppersmith Barbet (*Psilopogon haemacephalus*), Black-naped Oriole (*Oriolus chinensis*), Common Iora (*Aegithina tiphia*), and Yellow-vented Bulbul (*Pycnonotus goiavier*) in Greater Kuala Lumpur (Klang Valley). These six species are common colourful birds and have aesthetic value for urban biodiversity. The selected six bird species in the study are categorised as Least Concern in the IUCN Red List of Threatened Species and have conservation values toward urban ecosystems. We excluded abundant, feral, and introduced/invasive species such as the Eurasian Tree Sparrow (*Passer montanus*), Asian Glossy Starling (*Aplonis panayensis*), Rock Pigeon (*Columba livia*), House Crow (*Corvus splendens*), Peaceful Dove (*Geopelia striata*), Common Myna (*Acridotheres tristis*) and Javan Myna (*Acridotheres javanicus*), as well as swifts and swallows. Abundant, feral, and introduced/invasive species were excluded to reduce the bias in citizen science datasets because these factors can lead to an increase in the number of records by casual observers.

MATERIALS AND METHODS

Study Area

Malaysia consists of two regions, Peninsular Malaysia and Malaysian Borneo. Peninsular Malaysia comprises 11 of the 13 states of the country, including two of the three federal territories (Federal Territory of Kuala Lumpur and Federal Territory of Putrajaya). This study focused on the Central Region of Peninsular Malaysia (the Klang Valley region) comprising Kuala Lumpur, Putrajaya, and all Selangor districts except Kuala Langat, Kuala Selangor, Sabak Bernam and Hulu Selangor. Selangor is a metropolitan state that surrounds the two federal territories with a 6.56 million population (Figure 1). Kuala Lumpur is Malaysia's capital and largest metropolitan city, with a population of 1.808 million. Putrajaya is a planned city and the federal administrative centre of Malaysia with 91,900 population. Greater Kuala Lumpur has experienced rapid population growth and urbanisation, which has led to drastic changes in the landscape, with green space replaced by concrete infrastructure and high-rise developments. However, in Putrajaya, a large proportion of the land has been designated as a green space, with some artificial landscapes that consist of wetland parks, parks, roads, and green connectors.

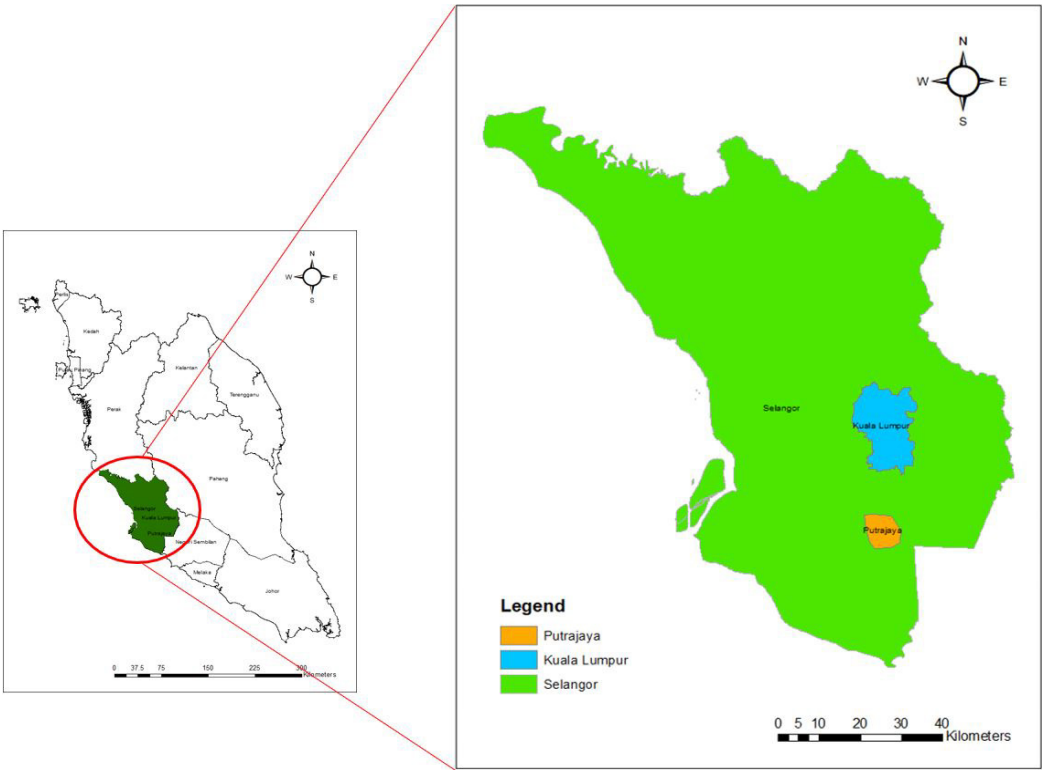

Figure 1. Map of Peninsular Malaysia (left) and the three areas selected for study—Selangor, Federal Territory of Kuala Lumpur, and Federal Territory of Putrajaya.

eBird Data

We used the online citizen science database eBird (https://ebird.org/home) easily accessible and used by researchers worldwide. eBird provides over 180,000 locations across the globe in a format that is accessible at any time. Observations data of the study bird species were downloaded to examine their distribution patterns in the metropolitan–urban–suburban region, particularly in Kuala Lumpur, Selangor, and Putrajaya. The dataset obtained from eBird provided all validated observations that consisted of observation dates, observer's id, specific locations, coordinates, and observation counts. The downloaded data were filtered to obtain only 'complete' checklists for inclusion in the study. The checklist of species was defined as 'complete' if 'stationary,' 'travelling,' or 'exhaustive' protocols were followed (Sullivan et al., 2014). We analysed the abundance and populations of the six bird species in the selected regions to identify differences in distribution patterns between urban and suburban areas.

Data Analysis

In order to address estimated position error, all distribution data for the year 2020 were analysed using ArcGIS 10.8 to ensure that the occurrences were within 100 m of the border of the study region. Distributions outside the study area were omitted. The Kernel Density tool was used to determine the density and distribution pattern of the urban bird species studied across Greater Kuala Lumpur. Kernels were analysed with a UTM Zone 48N projection at 1 km resolution. The Arc Toolbox was used to generate kernel estimators through Point Density in the Spatial Analyst Tools, and the data were processed in the same layer as the study area map. Kernel output was stretched using a histogram equaliser and resampled with the bilinear interpolation technique to enhance the appearance and smoothness of the raster data. The data were normally distributed (determined by inspection with quantile–quantile plots and the Shapiro–Wilk test). Species abundance was analysed with ANOVA in Minitab 19 software.

RESULTS AND DISCUSSION

A total of 5,538 occurrences of the urban bird species considered in this study were recorded across Greater Kuala Lumpur in 2020 in eBird (Table 1). Observations in 2020 suggest that three urban bird species, with the highest number of observations, were dominant in Greater Kuala Lumpur: the Yellow-vented Bulbul with 2,580 observations (46.59% of the total number of observations); Pink-necked Green-Pigeon with 1,066 observations (19.25%); and Black-naped Oriole with 720 observations (13.00%). In contrast, the Coppersmith Barbet had the lowest observations, with only 153 (2.76%).

Table 1
Occurrence of six urban bird species in 2020

Bird species	Occurrence	Percentage (%)
Yellow-vented Bulbul	2580	46.59
Pink-necked Green-Pigeon	1066	19.25
Black-naped Oriole	720	13.00
White-throated Kingfisher	552	9.97
Common Iora	467	8.43
Coppersmith Barbet	153	2.76

All six species were concentrated in the west and southeast, outside the Kuala Lumpur region (Figure 2), with each species' distribution varying across Greater Kuala Lumpur (Figure 3). Species abundance significantly differed across regions ($F = 5.12$, $p < 0.05$).

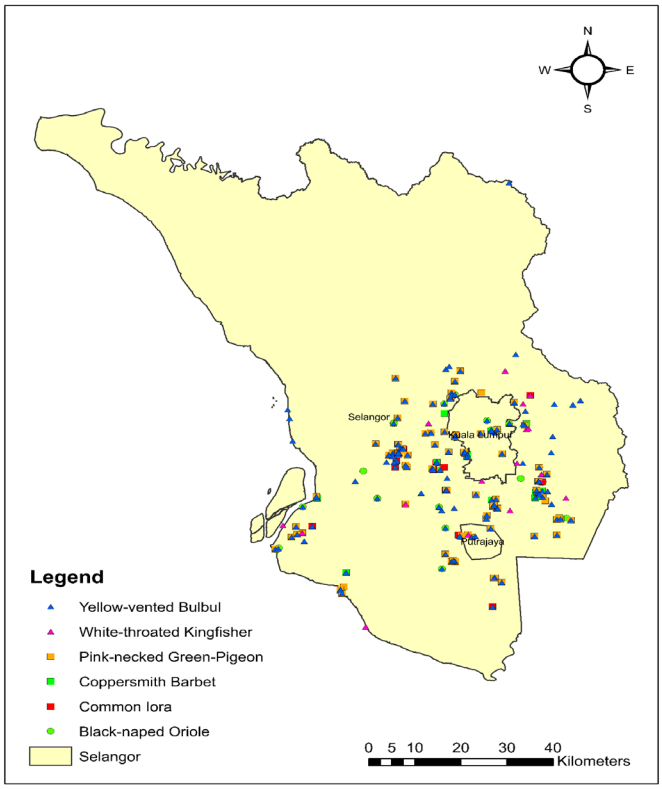

Figure 2. Distribution of the six urban bird species in Greater Kuala Lumpur in 2020

This study shows that the occurrence of the bird species studied increased with increasing distance from the Kuala Lumpur metropolitan centre. Urban birds are commonly found in open areas, residential areas and urban parks (Yusop et al., 2021). The green landscapes of Selangor include urban parks and street trees, which provide bird nesting and foraging opportunities (Mansor & Ramli, 2017; Zhou et al., 2012). Many new townships and developments in Selangor have allocated green areas that provide bird habitats (Puan et al., 2019). Urban birds make nests in trees and high-development areas (Seress & Liker, 2015). They show less intraspecific competition for food and habitats due to their high resistance to environmental tolerance and ability to develop niches in green areas since they have a broader geographic range size (Mohd-Taib et al., 2014; Palacio, 2020). The shape and size of the urban park also play an important role in supporting biodiversity and ecological functions (Jasmani et al., 2017). Medium- and small-sized green areas show higher rates of biotic relaxation than large-sized gardens, which have a high potential to provide nesting sites (Chaiyarat et al., 2019), indicating that habitats surrounding parks and street trees are crucial. The extent to which parks provide nesting sites is also determined by physical factors and anthropogenic disturbance (Aziz & Rasidi, 2013). The more

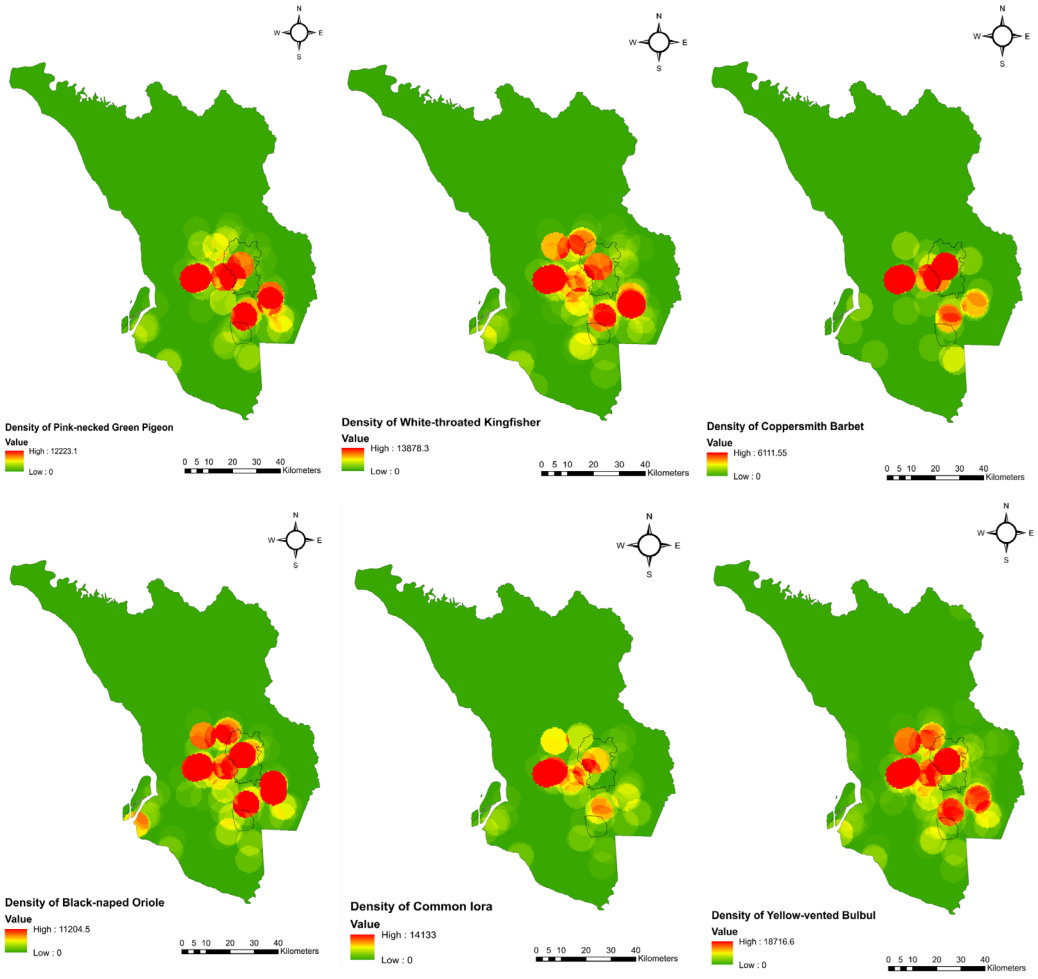

Figure 3. The density of the six urban bird species in Greater Kuala Lumpur in 2020: a) Pink-necked Green-Pigeon; b) White-throated Kingfisher; c) Coppersmith Barbet; d) Black-naped Oriole; e) Common Iora; and f) Yellow-vented Bulbul.

complex and heterogenous the vegetation, the higher the diversity of faunal species is in a given location (Mohd-Taib et al., 2014). Abundant green space in urban areas and sites connected by waterbodies and street trees enhances animal diversity (Puan et al., 2019). Therefore, including green areas in the city is crucial to maintaining urban bird diversity.

Kuala Lumpur has undergone drastic development over the past three decades to become one of the top 20 cities in the world by 2020 (Puan et al., 2019) estimated 2, 436 ha covered by the area of greenspace (Akmar et al., 2011), coupled with the lack of green spaces, has contributed to the low occurrence of urban birds in the city. The scarcity of green spaces and a high level of human activities in the metropolitan city limit the availability

of nesting sites and foraging opportunities, leading to a higher likelihood of urban birds preferring the outskirts. The increased size of city parks creates greater niche space for birds, resulting in higher habitat diversity and greater resource availability (Jasmani et al., 2017; Mansor et al., 2015). Other factors such as tree abundance, cleanliness, noise, human presence and traffic also affect urban biodiversity (Wilson et al., 2015). These factors impact the abundance and distribution of bird species in a given area depending on the current level of adaptation and niches that determine species survival.

The Yellow-vented Bulbul was the most abundant urban bird species in Greater Kuala Lumpur. However, it was highly different in number between Selangor (n=2503) and Kuala Lumpur (n = 169), indicating that population density may decline in metropolitan cities. Wells (2007) reported a decline in the population density of this bulbul species in Greater Kuala Lumpur. Without considering highly abundant or introduced species (e.g. the Eurasian Tree Sparrow, Peaceful Dove, Common Myna, Javan Myna and House Crow), the Yellow-vented Bulbul is considered among the most abundant urban bird species (Aida et al., 2016; Jasmani et al., 2017; Karuppannan et al., 2014; Puan et al., 2019). This bulbul is a widespread species found in almost all habitats except deep forests, ranging from mangrove forests to secondary forests, from farmland to plantations, and from the suburbs to the city. Urban areas consisting of open spaces, gardens, wetlands and vegetation are advantageous to urban birds that can adapt and find high levels of food (Idilfitri et al., 2014). Therefore, introducing a green corridor linking forested areas, street trees, gardens, and parks are important to ensure the survival of urban birds, such as recreational areas, cultural spaces and sports facilities for essential urban walking. A wide range of diets, including insects, carcasses, flowers, nectar, and fruits, guarantees their adaptation and population success.

Other abundant aesthetically valuable urban bird species in this study were the Pink-necked Green-Pigeon and Black-naped Oriole, probably due wide range of diets. Yellow-vented Bulbul and Black-naped Oriole are omnivores that eat insects and fruits due to the presence of figs (e.g. *Ficus benjamina*). Meanwhile, the Pink-necked Green Pigeon is a frugivore that seeks to eat fruit trees, shrubs and fruits from the palm trees (e.g. the Macarthur palm [*Ptychosperma macarthurii*]), which provide food and nesting places in the city along roadsides and parks (Malaysia Biodiversity Information System, 2021; Idilfitri et al., 2014; Jasmani et al., 2017). The wide range of diets for birds can influence the richness of urban bird species. Furthermore, these bird species are important in urban ecosystems because they are seed dispersers.

The important criteria of urban bird species are their ability to adapt to high-risk areas and proximity to human habitation when searching for food and alternative nesting sites (Daud et al., 2022; Idilfitri & Nik, 2012). According to (Moller, 2009), urban bird species have higher breeding rates than rural species due to their capacity to adapt to various conditions and use different sources of nutrition as needed. For example, the Pink-necked

Green Pigeon has successfully adapted to all types of urban and rural habitats, green areas in cities and urban parks (Malaysia Biodiversity Information System, 2021); it also favours swamps, mangroves and in-shore islet habitats (Wells, 2009). Aida et al. (2016) reported that most rural bird species have also adapted to the urban environment due to the suitability of urban centres that provide shelter similar to that found in rural areas resulting in the presence of similar trees and immensity of the green areas covered in those areas.

Among the six species studied, the Coppersmith Barbet has the lowest number of records in e-Bird. Its behaviour of foraging alone, in small groups or pairs, foraging in tree canopies for fruits and insects such as termites in cities may contribute to this result. Furthermore, the size of the bird may also contribute to the small number of records. Smaller birds and forage high in the canopy are more likely to be neglected by the public and birdwatchers compared to larger birds and lower-canopy foragers. The Yellow-vented Bulbul, Pink-necked Green-Pigeon and Black-naped Oriole have a larger body size of 20–32 cm compared to the Coppersmith Barbet, which is 16–17 cm in size. However, despite these factors, the great difference in the number of abundant species, coupled with the presence of invasive species such as crows and mynas, may lead to the instability of rare species and, consequently, reduce the likelihood of their survival in the future (Arazmi et al., 2022). Additionally, the predator-prey relationship, fertility, and territorial behaviour of this species may cause naturally occur in lesser numbers of species abundance.

CONCLUSION

Detailed analysis based on citizen science data, such as those recorded in eBird, can provide useful results and a reference to multiple stakeholders, such as town planners, developers, sociologists, economists, and conservationists, for effective urban planning and urban biodiversity management. City spaces and green areas are important in providing habitats for urban birds and are a central component of the urban ecosystem. In order to sustain urban biodiversity, parks in metropolitan cities should be improved by planting suitable trees and shrubs, green areas, such as gardens and parks, and roadside trees should be maintained to serve as a green corridor.

ACKNOWLEDGEMENTS

This study was funded by the Fundamental Research Grant Scheme (FRGS), Ministry of Higher Education Malaysia (MOHE), under grant FRGS/1/2020/STG03/UKM/02/5. We thank the numerous contributors to eBird, including observers, the project team, and data reviewers.

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