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Monetary evaluation of supporting ecosystem services as a habitat provider for birds in Thailand urban park

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Abstract. *Yarnvudhi A, Leksungnoen N, Siri S, Ponpithuk Y, Sukmasuang R, Duengkae P, Pongcharoen C, Sutummawong N, Marod D, Wachrinrat C, Premashthira A, Tor-ngern P, Poungcharean S, Hermuk S, Kachina P. 2022. Monetary evaluation of supporting ecosystem services as a habitat provider for birds in Thailand urban park. Biodiversitas 23: 4747-4758.* Supporting services are important services to maintain ecosystems by providing habitats for organisms and genetic diversity. In this study, the monetary value of supporting services for bird habitats in urban parks was evaluated based on the price for nursing each bird species and market value. Bird diversity was conducted using point count observation. We found total of 53 bird species, 27 families and 8 orders in the park. Total monetary benefit for bird habitats in this park was estimated to be around USD60,354.12 per individual bird with an average value of USD1,138.76 per bird per species. The top three species with the highest monetary value were the Painted Stork (*Mycteria leucocephala*), Asian Openbill (*Anastomus oscitans)*, and Chinese Pond Heron (*Ardeola bacchus*). The species diversity index of the bird community (H') was 2.73 and the most abundant bird species were Eastern Spotted Dove (*Spilopelia chinensis*), Eurasian tree sparrow (*Passer montanus*), Eastern jungle crow (*Corvus levaillantii*), Oriental magpie robin (*Copsychus saularis*), and Coppersmith Barbet (*Psilopogon haemacephalus*). Among 4 microhabitats, birds were found the most in the trees, followed by lawn, grassland, and wetland areas. The small urban parks should be designed with diverse microhabitats to provide various ecological functions to attract and ensure adequate resources for organisms.

Keywords: Bird diversity, ecological functions, ecosystem services, green space, microhabitats

INTRODUCTION

According to the United Nations (2019), the world's population is expected to grow to 8.5 billion in the year 2030 and potentially to 10.9 billion around the year 2100. As population growth and urbanization continue, cities are faced with many challenges, such as congestion, pollution, degraded water quality, problems related to waste disposal, and energy consumption exacerbated by an increasing population density. Such issues can be counteracted by sustainable urban development using urban green spaces, which function as sources of ecological diversity (Jasmani et al. 2017). Most studies focus on large-sized parks as hubs of biodiversity, providing various ecosystem services or ES (Yang et al. 2020). On the other hand, studies such as that by (Shahhoseini et al. 2015) have suggested that small urban parks should be given equal attention because of their potential to supplement the overall urban biodiversity. Urban green spaces are key to contribute direct and indirect benefits for the urban population (Jennings et al. 2016) through their ecosystem services (ES). The ES of an urban green space ecosystem can be separated into 4 parts (TEEB 2010) in (i) regulating services as an indirect use the air, water and soil quality, flood prevention and pest control as well as the pollution reduction (Yarnvudhi et al. 2021a); (ii) provisioning services from the direct use such food (meat, eggs, and nests), raw materials (wood, nests, and feathers), however, these services found less in the city as the ecology of urban different from natural habitats; (iii) culturing services such as the artistic and recreation activities such bird watching and photography, for which the patrons are willing to pay (Bejranonda and Attanandana 2011; Yarnvudhi et al. 2021b); (iv) supporting services maintain the three services mentioned above to sustain the genetic diversity and habitat for various species (TEEB 2010).

Many studies have focused on supporting services and included those on net primary production (NPP) (Almeida et al. 2018), nutrient cycling (Livesley et al. 2016), genetic diversity (Markowski et al. 2021) and habitat suitability for species, especially for avifauna (Round 1990; Lim and Sodhi 2004; Perry et al. 2008; Chaiyarat et al. 2019; Thaweepworadej and Evan 2022). Bird diversity has been studied in various urban ecosystems around the world (Campos-Silva and Piratelli 2020; Lee et al. 2021; Lerman et al. 2021), given the relative ease of survey as they can be frequently observed during the day (Khanaposhtani et al. 2012). Functions of birds in urban areas are diverse, ranging from controlling insects, pollinating, and nutrient return to the soil. Moreover, bird diversity affects the well-being of humans through visual and auditory perception, which in turn, can lead to mental relaxation and improvement in general health (Díaz et al. 2022). Birds can be good indicators for the quality and quantity of the environment (Fraixedas et al. 2020) as they can readily respond to changes in habitat fragmentation and shifts in habitat quality (Latta et al. 2018). Therefore, bird communities are often studied to assess the conservation status and general monitoring of parks (Naithani et al. 2018).

Bird diversity in urban parks in Thailand has been reported previously by Chaiyarat et al. (2019) in 10 different park sizes (community park to regional park size). They concluded that the size of a park could affect bird diversity, with larger parks having more bird species. The five bird species with the highest abundance within the 10 urban parks were Rock pigeon (*Columba livia*), Common Myna (*Acridotheres tristis*), Eurasian tree sparrow (*Passer montanus*), Zebra dove (*Geopelia striata*), and Eastern jungle crow (*Corvus macrorhynchos*). A similar study was done in nine small urban parks (with a park size between 0.5-3.5 ha) in Petaling Jaya, Malaysia, by Jasmani et al. (2017). They concluded that small urban parks might not host as much diversity as larger parks and indicated that the most abundant bird species were Eurasian tree sparrow, Oriental magpie robin (*Copsychus saularis*), and House crow (*Corvus splendens*). These birds are native species that contribute to the structure, biomass, and energy turnover of the environment they live in (Gaston et al. 2018). Peris and Montelongo (2014) reported that the park size had the most influence on bird richness in the 20 urban parks (between 0.11-8.6 ha) located in Salamanca, Spain, with the most abundant bird species being the House sparrow (*Passer domesticus*), an observation which has been made in other parks worldwide (Zhou et al. 2012; Nielsen et al. 2013; Schutz and Schulze 2015; Lee et al. 2022).

Even the bird diversity has been studied and reported previously, to our knowledge, limited reports estimated the monetary value of supporting services of a park as habitats for bird species (Clucas et al. 2014; Johnson and Hackett 2016). The monetary value of various ecosystem services can be estimated by using the available market prices, such as fresh water, timber prices, to estimate the provisioning services (Gren and Amuakwa-Mensah 2018; Tinga et al. 2021) or regulating services using models such as i-Tree (Nowak 2017), InVest (Hamel et al. 2021), and ARIES (Villa et al. 2014). However, researchers attempted to evaluate the non-market value of abstract and intangible to determine the monetary value of such services (Hanemann 1994; Spash and Hanley 1994; TEEB 2010). In this study, we focused on evaluating bird species' monetary value as a result of supporting services of an urban park in Bangkok, Thailand. For some wildlife species, a direct market price was used to determine the monetary value per species by Round (1990), who explored the ongoing trade of species in markets for selling live avifauna, mammals, and reptiles in weekend markets in Bangkok, Thailand but not in the park. Based on the market price and the information by the National Parks Wildlife and Plant Conservation Department (DNP), we examined the supporting ecosystem services such as bird microhabitats and bird diversity in order to estimate the monetary value of each bird species. Such estimation of supporting services can help the local authorities or city planners while designing future small urban green spaces to increase biodiversity as well as to maintain the urban ecosystem for sustainability.

MATERIALS AND METHODS

Study area

Bangkok is the capital city of Thailand, with an area of 156,873 ha (World Bank 2022b). There are 37 urban parks in Bangkok (BMA 2021), among which is the "Chulalongkorn University Centenary Park" (CU 100 Park), which was converted from a junk shop to a park in 2016. It is spread over a total area 4.48 ha (Figure 1) and is located in the center of the business district to increase the area under green space in Bangkok (ONEP 2017). The park was carefully planned and designed for climate change mitigation related to frequent flooding, with an additional purpose to serve the local community and enhance and/or preserve ecological biodiversity. The park is divided into different microhabitats for human and animal use, especially birds and includes wetlands, lawns, grasslands, and trees (Chulalongkorn University Centenary Park 2016) (Figure 1). Each habitat consists of various food sources and shelters for the bird species (Table 1).

Procedures

Field data collection for birds

This study was conducted two days in each month from August 2018 to July 2019 (bird counts n: 24). Point-count method (Bibby et al. 1992) was used to observe and record all the birds either through hearing for specific bird sounds or visually through binoculars (Nikon eyepiece 10 x10mm., Japan) and a digital camera (Nikon Z50, Japan). Observations were along the park trail line of 600 meters within radius of 20 meters. Totals of 14-point counts were used with a counting period of 12 min per point-count wait (Bibby et al. 1992; Round and Brockelman 1998) from 6.00-9.00 AM on each selected day. All the avian species were identified by experts (Dr. Supalak Siri and Yuwadee

Ponpithuk) from the Department of Forestry Biology, Faculty of Forestry and were compared with the bird species guide book of Thailand (Lekagul and Round 1991), Thai Bird Checklist (Bird Conservation Society of Thailand 2018), the Wild Animal Reservation and Protection Act B.E. 2546 (A.D. 2003), and the International Union for Conservation of Nature (IUCN) red list of threatened species (IUCN 2022).

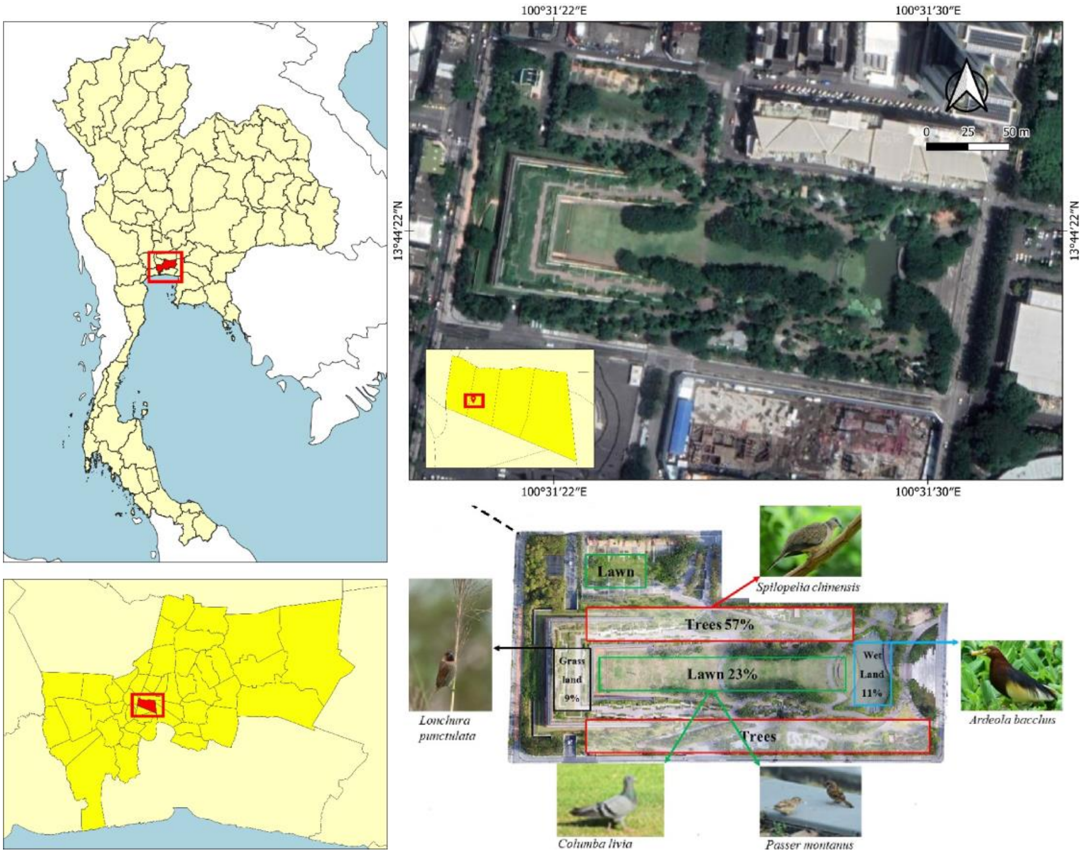

Figure 1. Location of Chulalongkorn University Centenary Park (CU 100 Park), Bangkok, (long. 13.73’N, lat. 100.52’E), with percentage number of species in the micro-habitat of the park (Chulalongkorn University Centenary Park 2016). Photographs are the samples of dominant species found in each microhabitat (photographed by Yuwadee Ponpithuk)

Table 1 Microhabitats of birds for feeding and shelter in the Chulalongkorn University Centenary Park, Bangkok, Thailand

Micro-habitats	Definition	Area (% of total area)	Food (Fish/plants/grasses)	References
Wetlands	Rainwater reservoir, constructed wetland, and retention pond with 12 fish species	20%	*Cyprinus carpio*, *Gambusia affinis*, *Poecilia reticulata*, *Poecilia sphenops*, *Xiphophorus maculatus*, *Clarais hybrid*, *Pterygoplichthys pardalis*, *Oreochromis niloticus*, *Anabas testudineus*, *Trichogaster trichopterus*, *Trichopsis vittatus*, *Channa striata*	Surveyed and identified by the expert from Faculty of Fisheries, Kasetsart University, Bangkok, Thailand (i.e., Dr. Santi Poungcharean)
Lawn	Short grass	20%	*Zoysia matrella*, *Cynodon dactylon*	Park Management Chulalongkorn University (PMCU)
Grassland	Long grass, bushes, and shrubs	25%	*Panicum repens*, *Pennisetum purpureum*, *Pennisetum pedicellatum*, *Melinis repens*, *Massia triseta*, *Vetiveria zizanioides*, *Cynodon dactylon*, *Typha angustifolia*, *Ruellia tuberosa*, *Gomphrena celosioides*, *Wrightia antidysenterica*, *Gardenia jasminoides*	Park Management Chulalongkorn University (PMCU)
Trees	61% Deciduous 39% Evergreen	35%	*Azadirachta indica*, *Shorea roxburghii*, *Millettia leucantha*, *Xylia xylocarpa*, *Dalbergia cochinchinensis* (high monetary value) *Albizia saman*, *Dalbergia cochinchinensis*, *Tabebuia rosea*, *Millingtonia hortensis*, *Dipterocarpus alatus* (most dominant species)	Yarnvudhi et al. (2021a)

Data analysis

Bird species status, guild feeding, and threat status

Bird species status was categorized into 2 groups according to the recommendations of the migratory Bird Conservation Society of Thailand (2018), including; breeding resident (R) (species actually breeding or within the breeding range) and non-breeding resident (N) (Table 2). The feeding type was assigned to six categories (carnivore, frugivore, granivore, insectivore, nectarivore, and omnivore), which are the species groups that require similar habitat, food, or other elements for survival, and were the populations of species dependent on a particular resource. According to Ali (1996), each species is important for their dietary guilds, which were categorized into 17 classes of behavioral response dietary guilds as AF (Arboral frugivore), AIF (Arboreal insectivore/frugivore), C (Carnivore), F (Frugivore), FGI (Foliage-gleaning insectivore), FGI/AF (Foliage-gleaning insectivore/ Frugivore), G (Granivore), G/I (Granivore/ insectivore), IN (Insectivore/nectarivore), Ins (Insectivorous), M (Molluscivore), O (Omnivore), P (Piscivore), Sal (Sallying insectivore), Sc (Scavenger), Swl (Sweeping insectivore), TIF (Terrestrial insectivore). The threat status was determined following the national (ONEP 2017) and global (IUCN 2022) status checklist of Thai birds (Bird Conservation Society of Thailand 2018).

Relative abundance (RA)

RA was used as a frequency index to indicate how often the birds were observed in the park and was calculated using the formula suggested by Pettingill (1984);

$$RA\ (\%) = n_i / N*100$$

Where, n_i is the number of individuals of a species taken into account and N is the total number of individuals of all species. Species relative abundance status (Table 1) was estimated from the frequency of observation over 12 months. Pettingill (1984) also suggested a classification of species abundance with RA: 90-100% as being abundant, 65-89% as common, 31-64% as moderately common, 10-30% as uncommon, and 1-9% as being rare.

Monetary evaluation

The monetary value of birds found in the CU100 park was based on a market value studied by Round (1990) and the price provided by the National Parks Wildlife and Plant Conservation Department (DNP). In Round (1990), the market value was listed for common species selling in the open market, which consisted of only 5 species in this study, including Eastern Spotted Dove (*Spilopelia chinensis*), Zebra Dove (*Geopelia striata*), Thick-billed Green Pigeon (*Treron curvirostra*), Red-whiskered Bulbul (*Pycnonotus jocosus*), and Scaly-breasted Munia (*Lonchura punctulata*). For the other 48 species that were not on the list of Round (1990), the DNP provided the information of nursing expenses for birds covered from newborns until they reached a mature stage of growth (2-4 years). For example, the monetary value for Oriental Magpie Robin (*Copsychus saularis*) was USD644.41 bird-1. This species reached the mature stage at 2 years; thus, the estimation was calculated from caretaking salary (USD83.82) + nourishment (USD32.21) + medicine (USD44.12) + disease control (USD29.41) bird-1 yr-1 (total: USD189.56 yr-1) multiplied by 2 as the total time for a caretaker with the total of USD379.42. Then, the cage size of 25 m x 5 m (USD265.29) was added, yielding the total monetary value of this species of USD644.41 (Table 2).

Species diversity

Shannon-Wiener diversity index (H') (Shannon 1949) was calculated using the Species Diversity and Richness program ver. 2.62 (Henderson and Seaby 1998) as follows;

$$H' = -\sum_{i=1}^{s} (pi)\ (ln \quad pi)$$

Where, pi is the proportion of individual species times the total number of all species (when i: species of 1, 2, 3,..., s), s is the total number of species and $\log_2$ is the base 2 logarithm. H': less than 1.5 indicates low diversity, between 1.5-3.5 indicate moderate, and value higher than 3.5 is considered high species diversity (Magurran 2004).

Species evenness

The evenness index (E) indicates the individual number of species in a given ecosystem and was calculated using the following formula (Pielou 1966);

$$E = H'/In\ S$$

Where, H' is Shannon-Wiener diversity index and S is the total number of species.

Similarity index

The similarity index was used to compare the number of bird species found in CU100 park with the previous study conducted by Chaiyarat et al. (2019), who investigated the similarity of bird species among 10 mainland parks in Bangkok, Thailand. The similarity index was calculated following Krebs (1972) as:

$$IS = 100*(2w)/A+B$$

Where, A is the total number of bird species found in CU 100 Park, B is the total number of bird species reported by Chaiyarat et al. (2019) and Sananunsakul et al. (2017) (Table 3) and W is the number of bird species common in both A and B.

RESULTS AND DISCUSSION

Bird species status, guild feeding, threat status, and relative abundance

Throughout the period of study (from August 2018 to July 2019) in the CU 100 park, a total of 53 bird species in 27 families and 8 orders were found. Passeriformes were the most frequently found with 19 families and 25% of non-breeding visitors and 75% of resident species breeding or known to have bred in Thailand (Bird Conservation Society of Thailand 2018). The dietary guilds of birds and categorized behavior of feeding guilds was dominated by the insectivore group (28%) (insectivorous, sallying insectivore, sweeping insectivores, and foliage gleaning insectivores), 21% omnivores (arboreal insectivores/ frugivore, frugivores, foliage-gleaning insectivores/ frugivore, granivores, scavengers, and terrestrial insectivores), 19% granivores (granivores/insectivores, granivores, arboreal frugivores), 17% carnivores (carnivore, omnivore, molluscivore, piscivore), 9% frugivores (arboreal frugivore, arboreal insectivore/frugivore), and 6% nectarivores (insectivores/ nectarivores) (Table 2).

Instead, based on species richness of birds feeding type, 15% of species belonged to the insectivore group identified in the trees and grasslands. The number of species in the micro-habitats was found 57% on trees, 23% on the lawn, 11% on wetland, and 9% on grassland (Figure 1). The most abundant bird species (Eurasian tree sparrow) was found on the lawn areas as the open spaces was frequented by granivores (grass seed), insectivores (earthworm), and omnivores as it was the only food source for such species. The highest species richness was observed in the tree areas as the structure of trees is suitable for species feeding and trees were a source of various food types and conducive for nesting for insectivores, omnivores, granivores, frugivores, carnivores, and nectarivores. The grassland areas had tall grass and shrubs cover, which are potential feeding sources and secure nesting places and had the highest abundance of Scaly-breasted Munia (*Lonchura punctulata*) (in the granivore group), with species richness including insectivores, granivores, frugivores, and omnivores. The wetland areas had the highest abundance of House Swift (*Apus nipalensis*) from the insectivore group, given that aquatic insects were readily found near thick vegetation and water along the banks of the retention pond. Striated Heron (*Butorides striata*), White-breasted Waterhen (*Amaurornis phoenicurus*) and Chinese Pond Heron (*Ardeola bacchus*) was high in wetland areas as there was no competition for food sources. Thus, microhabitats provide functional connectivity between the park and urban area, which could enhance the diversity of bird species in each feeding type (Figure 2).

High diversity and abundance in the park reported in this study could be due to the presence of a greater number of common species in the available feeding guilds. The species that are threatened by global extinction were the Painted Stork (*Mycteria leucocephala*) and Asian Golden weaver (*Ploceus hypoxanthus*) (IUCN 2018). Red Avadavat (*Amandava amandava*) has been listed under the near threatened list in the national threat status report of (Bird Conservation Society of Thailand 2018). The species with less than 2 individuals during the study period were Black-crowned Night Heron (*Nycticorax nycticorax*), White-throated Kingfisher (*Halcyon smyrnensis*), Red Avadavat, Blue Rockthrush (*Monticola solitarius*) and were found in the rainy season. Red-whiskered Bulbul (*Pycnonotus jocosus*), Asian Emerald Cuckoo (*Chrysococcyx maculatus*), Plain-backed Sparrow (*Passer flaveolus*), and Thick-billed Green Pigeon (*Treron curvirostra*) were found only during the cold dry season (Dec-Feb). Brown-throated Sunbird *(Anthreptes malacensis*), Asian Golden Weaver (*Ploceus hypoxanthus*), and Yellow-bellied Prinia (*Prinia flaviventris*) were found only one time during the hot dry season (Apr-May) near the wetlands.

Assessing avifauna monetary value

In this study, we estimated the monetary value of bird species by combining the values obtained from wildlife National Park, Wildlife and Plant Conservation Department (DNP) and the traded market value reported by Round (1990). The total monetary value was USD60,354.12, with an average of USD1,138.76 per bird per species. The three species with the highest monetary value were the Painted Stork (*Mycteria leucocephala*) (USD6,491.18), Asian Openbill (*Anastomus oscitans*) (USD6,491.18), and Chinese Pond Heron (USD3,213.24). Painted Stork, which was stated as being near threatened in the Bird Conservation Society of Thailand (2018) list, and we found only 2 times in January 2019. A low monetary value of USD644.41 was 29 species for example, Eurasian Tree Sparrow, Eastern Jungle Crow, and Oriental magpie robin, which are common species in the urban landscape (Table 2).

Species diversity and evenness, similarity index

The average bird diversity index was moderate (H': 2.73) in the area based on mixed vegetation of evergreen and deciduous forests (Table 1). The evenness was very low at 0.0075, given that it is a small park, and some species were found only once during the 12 months of observation. For example, non-breeding birds such as Blue Rockthrush, Asian Emerald Cuckoo, Chinese Pond Heron, and Painted Stork mostly migrate to warmer climates during winter in their native habitats and in search for food sources annually. The similarity index of bird species between the CU 100 park and other parks in Bangkok was compared reported (Table 3, Figure 3).

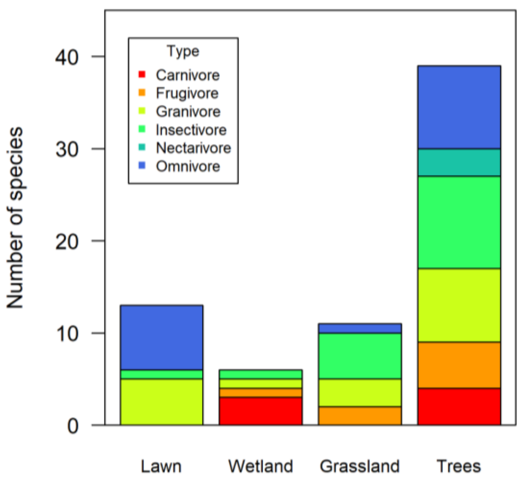

Figure 2 Number of bird species in 6 feeding guild types at 4 microhabitats in the Chulalongkorn University Centenary Park, Bangkok, Thailand

Table 2. List of bird species found in the Chulalongkorn University Centenary Park, Bangkok, Thailand during August 2018 to July 2019 with relative abundance and monetary value (ranged from high to low in each relative abundance group)

Species name	Common name	Family	Status	Dietary guild	Feeding type	Micro habitat	Global threat status	National Threat Status (ONEP)	Relative abundance (%)	Monetary value (USD) per species
Spilopelia chinensis	Eastern Spotted Dove	Columbidae	R	G	Granivore	1,4	LC	LC	100	1,102.94
Passer montanus	Eurasian Tree Sparrow	Passeridae	R	G/I	Granivore	1,3	LC	LC	100	644.41
Corvus levaillantii	Eastern Jungle Crow	Corvidae	R	Sc	Omnivore	1,4	LC	LC	100	644.41
Copsychus saularis	Oriental Magpie Robin	Muscicapidae	R	TIF	Omnivore	1,4	LC	LC	100	644.41
Psilopogon haemacephalus	Coppersmith Barbet	Megalaimidae	R	AIF	Frugivore	4	LC	LC	100	644.41
Geopelia striata	Zebra Dove	Columbidae	R	G	Granivore	1,4	LC	LC	92	1,102.94
Columba livia	Rock Pigeon	Columbidae	R	G	Omnivore	1	LC	LC	92	1,100.00
Acridotheres grandis	White-vented Myna	Sturnidae	R	TIF	Omnivore	1,4	LC	LC	92	1,097.06
Streptopelia tranquebarica	Red Collared Dove	Columbidae	R	F	Omnivore	1,4	LC	LC	92	1,097.06
Gracupica contra	Asian Pied Myna	Sturnidae	R	TIF	Omnivore	1,4	LC	LC	92	1,097.06
Pycnonotus goiavier	Yellow-vented Bulbul	Pycnonotidae	R	AIF	Frugivore	3,4	LC	LC	92	1,097.06
Lonchura punctulata	Scaly-breasted Munia	Estrildidae	R	G	Granivore	1,3,4	LC	LC	92	645.59
Prinia inornata	Plain Prinia	Cisticolidae	R	Ins	Insectivore	3	LC	LC	92	644.41
Rhipidura javanica	Malaysian Pied Fantail	Rhipiduridae	R	Sal	Insectivore	3,4	LC	LC	92	644.41
Pycnonotus conradi	Streak-eared Bulbul	Pycnonotidae	R	AIF	Frugivore	3,4	LC	LC	83	1,097.06
Acridotheres tristis	Common Myna	Sturnidae	R	TIF	Omnivore	1,4	LC	LC	83	1,097.06
Gracupica nigricollis	Black-collared Myna	Sturnidae	R	TIF	Omnivore	1,4	LC	LC	83	1,097.06
Cypsiurus balasiensis	Asian Palm Swift	Apodidae	R	Swl	Insectivore	5	LC	LC	83	644.41
Cinnyris jugularis	Olive-backed Sunbird	Nectariniidae	R	IN	Nectarivore	4	LC	LC	83	644.41
Dicaeum cruentatum	Scarlet-backed Flowerpecker	Dicaeidae	R	AF	Frugivore	4	LC	LC	83	644.41
Eudynamys scolopaceus	Asian Koel	Cuculidae	R	FGI/AF	Omnivore	4	LC	LC	75	1,097.06
Anastomus oscitans	Asian Openbill	Ciconiidae	R	M	Carnivore	5	LC	LC	67	6,491.18
Butorides striata	Striated Heron	Ardeidae	R	P	Carnivore	2,4	LC	LC	58	2,630.88
Apus nipalensis	House Swift	Apodidae	R	Swl	Insectivore	2	LC	LC	42	644.41
Lanius cristatus	Brown Shrike	Laniidae	N	C	Carnivore	4	LC	LC	42	644.41
Lanius collurioides	Burmese Shrike	Laniidae	N	C	Carnivore	4	LC	LC	42	644.41
Oriolus chinensis	Black-naped Oriole	Oriolidae	N	AIF	Omnivore	4	LC	LC	33	1,097.06
Aegithina tiphia	Common Iora	Aegithinidae	R	FGI	Insectivore	4	LC	LC	33	644.41
Ardeola bacchus	Chinese Pond Heron	Ardeidae	N	P	Carnivore	2	LC	LC	25	3,213.24
Cacomantis merulinus	Plaintive Cuckoo	Cuculidae	R	FGI	Insectivore	4	LC	LC	25	1,097.06
Phylloscopus inornatus	Yellow-browed Leaf Warbler	Phylloscopidae	N	FGI	Insectivore	4	LC	LC	25	644.41
Hirundo rustica	Barn Swallow	Hirundinidae	N	Swl	Insectivore	5	LC	LC	17	644.41
Arundinax aedon	Thick-billed Warbler	Acrocephalidae	N	FGI	Insectivore	3,4	LC	LC	17	644.41
Dicrurus leucophaeus	Ashy Drongo	Dicruridae	N	Sal	Insectivore	4	LC	LC	17	644.41
Mycteria leucocephala	Painted Stork	Ciconiidae	N	M	Carnivore	5	NT	NT	8	6,491.18
Nycticorax nycticorax	Black-crowned Night Heron	Ardeidae	R	P	Carnivore	2,4	LC	LC	8	2,048.53
Amaurornis phoenicurus	White-breasted Waterhen	Rallidae	R	O	Carnivore	2	LC	LC	8	1,466.18

Treron curvirostra	Thick-billed Green Pigeon	Columbidae	R	AF	Granivore	4	LC	LC	8	1,100.00
Pycnonotus jocosus	Red-whiskered Bulbul	Pycnonotidae	R	AIF	Frugivore	4	LC	LC	8	1,108.82
Treron vernans	Pink-necked Green Pigeon	Columbidae	R	AF	Granivore	4	LC	LC	8	1,097.06
Chrysococcyx maculatus	Asian Emerald Cuckoo	Cuculidae	N	FGI	Insectivore	4	LC	LC	8	1,097.06
Passer domesticus	House Sparrow	Passeridae	R	G/I	Granivore	1,4	LC	LC	8	644.41
Lalage melaschistos	Black-winged Cuckooshrike	Campephagidae	N	FGI	Insectivore	4	LC	LC	8	644.41
Orthotomus sutorius	Common Tailorbird	Cisticolidae	R	FGI	Insectivore	3	LC	LC	8	644.41
Muscicapa dauurica	Asian Brown Flycatcher	Muscicapidae	N	Sal	Insectivore	4	LC	LC	8	644.41
Cinnyris asiaticus	Purple Sunbird	Nectariniidae	R	IN	Nectarivore	4	LC	LC	8	644.41
Amandava amandava	Red Avadavat	Estrildidae	R	G	Granivore	3	LC	NT	8	644.41
Anthreptes malacensis	Brown-throated Sunbird	Nectariniidae	R	IN	Nectarivore	4	LC	LC	8	644.41
Halcyon smyrnensis	White-throated Kingfisher	Alcedinidae	R	P	Carnivore	5	LC	LC	8	644.41
Monticola solitarius	Blue Rockthrush	Muscicapidae	N	TIF	Omnivore	1,4	LC	LC	8	644.41
Passer flaveolus	Plain-backed Sparrow	Passeridae	R	G/I	Granivore	1,4	LC	LC	8	644.41
Ploceus hypoxanthus	Asian Golden Weaver	Ploceidae	R	G/I	Granivore	2,3	NT	NT	8	644.41
Prinia flaviventris	Yellow-bellied Prinia	Cisticolidae	R	Ins	Insectivore	3	LC	LC	8	644.41

Note: N: Non-breeding; R: Resident. Dietary guild: AF: Arboreal frugivore; AIF: Arboreal insectivore-frugivore; C: Carnivore; F: Frugivore; FGI: Foliage-gleaning insectivore; FGI/AF: Foliage-gleaning insectivore/ Arboreal frugivore; G: Granivore; G/I: Granivore/ insectivore; IN: Insectivore/nectarivore; Ins: Insectivorous; M: Molluscivorous; O: Omnivore; P= Piscivore; Sal: Sallying insectivore; Sc: Scavenger; Swl: Sweeping insectivore; TIF: Terrestrial insectivore (Ali 1996). Microhabitat: 1: Lawn; 2: Wetland; 3: Grassland; 4: Trees; 5: Fly. Threat status: NT: near-threatened; LC: Least concern. Relative abundance: 90-100%: Abundant; 65-89%: common; 31-64%: moderately common; 10-30%: uncommon; 1-9%: rare. Currency: USD1: THB34.00 (World Bank 2022a).

Table 3. Bird species diversity, and evenness in the Chulalongkorn University Centenary Park (during August 2018 to July 2019) and the comparison with other parks and green areas of Bangkok, Thailand in previous reports

Urban parks	Area (ha)	Number of species	Shannon-Wiener	Evenness	Similarity (percent)	References
Chulalongkorn University Centenary Park	4.48	53	2.73	0.0075	100	In this study
Suan Luang Rama IX	80	34	0.98	0.64	59.77	Chaiyarat et al. 2019
Phutthamonthon	400	39	1.17	0.74	54.35	Chaiyarat et al. 2019
Wanadham	6.1	18	1.02	0.81	53.33	Chaiyarat et al. 2019
Thonburirom	10.1	24	0.95	0.69	51.95	Chaiyarat et al. 2019
Thawiwanarom	8.6	23	1.08	0.79	50.00	Chaiyarat et al. 2019
Queen Sirikit	31.5	28	1.03	0.71	49.38	Chaiyarat et al. 2019
Wachirabenchatat	60	29	1.04	0.71	48.78	Chaiyarat et al. 2019
Anantara Siam Bangkok Hotel	0.26	18	2.43	-	42.25	Sananunsakul et al. 2017
Santichaiprakan	1.4	16	0.69	0.58	40.58	Chaiyarat et al. 2019
Santipap	3.2	17	0.64	0.52	40.00	Chaiyarat et al. 2019
Mahitaladhibesra Building	0.03	13	2.21	-	36.36	Sananunsakul et al. 2017
Rommaninart	4.8	22	0.97	0.72.	36.11	Chaiyarat et al. 2019
Padtayapattana Building	0.09	12	2.22	-	33.85	Sananunsakul et al. 2017
Siam Green Sky	0.11	11	1.62	-	31.25	Sananunsakul et al. 2017
60th Anniversary Building	0.11	10	1.82	-	28.57	Sananunsakul et al. 2017
SG Tower	0.02	7	1.63	-	23.33	Sananunsakul et al. 2017
Mitkorn Mansion	0.07	10	1.92	-	22.22	Sananunsakul et al. 2017

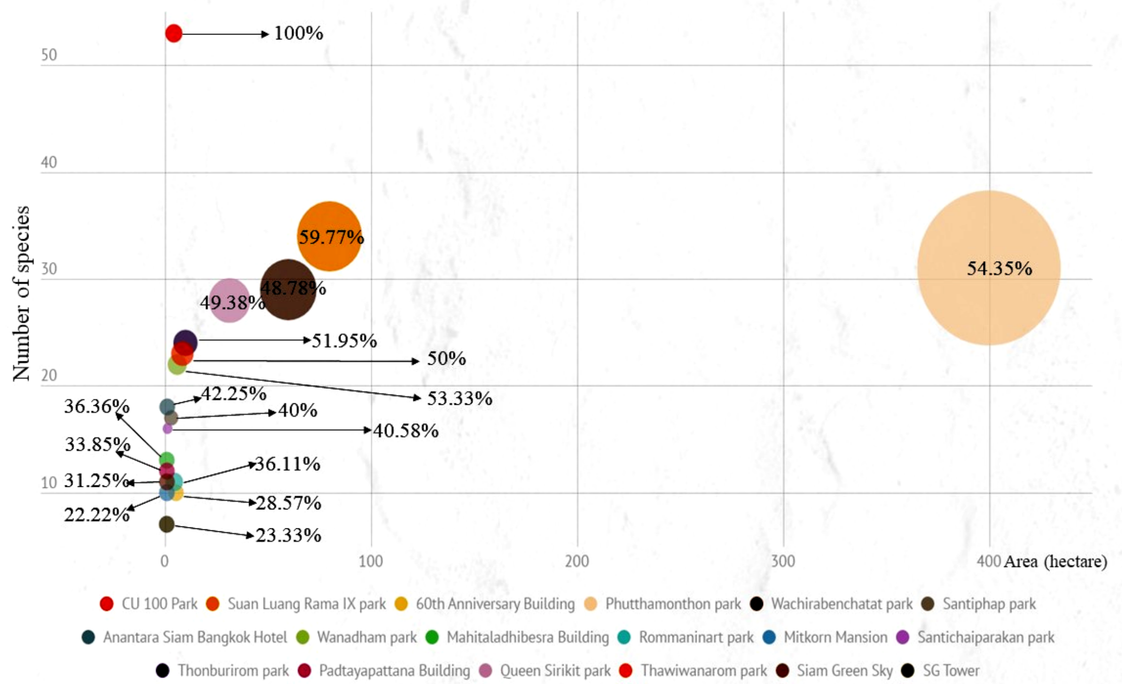

Figure 3 Numbers of bird species in urbans in Bangkok, Thailand regarding to the size of the park (the enlarged size of the circle indicates the large area). While the number in the circle as % represents the similarity index of the number of species in the Chulalongkorn University Centenary Park relative to other 10 parks and 7 green areas in Bangkok, Thailand (Sananunsakul et al. 2017; Chaiyarat et al. 2019)

The number of birds in the CU 100 park had the greatest similarity with the Suan Luang Rama IX park (59.77%) followed by Phutthamonthon (54.35%) and Wanadham (53.33%), as bird species such as Rock pigeon, Eurasian tree sparrow, Oriental magpie robin, Ayeyarwady Bulbul (*Pycnonotus blanfordi*), and Zebra dove are the most commonly found in such urban areas. However, the Rommaninart park, the size of park is the same as in this study (4.8 ha), showed a low similarity index (36.11%), whereas the smaller green space in the Anantara Siam Bangkok Hotel (0.26 ha) and the Mahitaladibesra building (0.03 ha) had an average similarity percentage of 42.25 and 36.36%, respectively. Thus, the high similarity of the common urban species in this study might be due to the size of the park or the food sources and refuge availability in these areas but due to the variation of microhabitats in the park.

Discussion

The goal of this study was to examine the ES, especially the supporting services as bird habitat, in terms of monetization of bird species residing in the CU 100 park. In addition, we also analyzed the effect of microhabitats on the number and abundance of bird species and compared the bird species with those previously reported in parks around Thailand (Chaiyarat et al. 2019). In our study, the contribution of monetary value offered supporting services in the CU 100 park was 19.86% relative to other services provided by this CU 100 park, which has been reported by Yarnvudhi et al. (2021a) and (2021b) while that provided by the culturing, provisioning, and regulating services was 46.79%, 27.81% and 5.54% respectively. However, in this study, the monetary valuation for supporting services did not cover all the services as there are other services such as soil nutrient recycling, soil formation, and habitats for other species such as insects, fungi, and reptiles, etc. Future studies should aim to estimate the monetary value of these services in order to evaluate the whole process of supporting the service of urban parks to society.

Birds not only matter economically through ES they provide but are also essential for human subsistence and fulfillment of living by providing aesthetics. In this study, the estimated monetary values of supporting services, as calculation of bird value was considered relatively low (USD1,138.76) when compared to similar estimations done for the Stockholm National Urban Park in Sweden, which Eurasian Jay (*Garrulus glandarius*) was estimated to be USD2,450 to USD11,250 per bird (Hougner et al. 2006). The method they used in Sweden was estimating the labor cost of replacing the seedlings or planting 2 tree species (*Quercus robur* and *Quercus petraea*) which are the food for the bird. Another study in urban Massachusetts estimated a value of USD28.25 per person per year by using the contingent valuation method to pay to conserve the bird species Bald Eagle (*Haliaeetus leucocephalus*) (Stevens et al. 1991).

The park size has been reported to affect the richness and diversity of bird species, with larger areas consisting of a higher number of species (Carbó-Ramírez and Zuria 2011; Chaiyarat et al. 2019). Bird diversity in 10 parks in Bangkok, with an area between 3.2-400 ha, ranged from 0.64-1.17 (Chaiyarat et al. 2019), which is as lower than that estimated in this study (H': 2.73 in an area of 4.48 ha) (Table 3). The bird diversity in seven small green roof areas in Bangkok, with sizes between 0.02-0.26 ha, ranged from 1.62-2.43 (Sananunsakul et al. 2017), which is lower than calculated in this study, as the coverage area on green roofs may provide some protection against inclement weather protection from strong winds (Table 3). The bird diversity index in 9 parks around Malaysia, estimated by Jasmani et al. (2017), was moderate (H': 2.19) with the highest index of 2.73 in an area of 2.5 ha. This indicates that park size is important for diversity, but small parks can also have high bird diversity if the park contains several microhabitats and food sources (Snep et al. 2016). The heterogeneity of microhabitats is key to increase the bird diversity and in turn, the visitation frequency in the park. Even though the CU 100 park is relatively small in size, a careful design of vegetation structure of 20% of wetland (pond and manmade streams) provided habitat for nesting and foraging to water birds, especially Asian Openbill and Painted Stork. Our observations were similar to the study of Kim et al. (2007), who suggested that a small urban park can also have higher bird diversity if the water bodies and diverse vegetation is properly managed. In addition, vegetation complexity can increase the species richness of forest birds (Husté et al. 2006; Evans et al. 2009; Kang et al. 2015). This is, especially the case in urban habitats where the presence of a shrub layer has been shown to be important to have diversity in bird species, especially that nest on or close to the ground (Tilghman 1987).

Campos-Silva and Piratelli (2020) suggested that habitat fragmentations to be microhabitats could increase the resources and support habitat and several amounts of feeding sources provide for birds, especially the presence of dead trees that are a habitat for various species. However, these suggestions might be difficult to implement in the CU 100 park to maintain the aesthetics and safety of the park, as dead trees would have to be summarily removed and replaced with new trees. Chaiyarat et al. (2019) suggested that to maintain and expand large parks cities in terms of increasing the biodiversity and complexity of the urban ecosystem, areas under grassland would have to be increased, more trees would have to be planted, area under wetlands in surrounding park areas would have to be increased. Wood and Esaian (2020) found that birds fed on a variety of native and nonnative trees and consumed leaf surfaces, flowers, and fruits. They also observed that the nonnative vegetation might provide food sources outside of the typical seasonal patterns of adjacent natural areas. Yang et al. (2020) studied the influence of park characteristics on bird diversity in Nanjing city parks and found that apart from the park area, habitat diversity and distance to the city center were the most important factors positively affecting the richness of bird species. They indicated that diverse habitat types could cater to the requirements of living spaces for birds, such as mixed species from various forest types, canopy layer trees, and dense shrubs, which can have a high richness of bird species.

In this study, we found that the number of species per hectare was 11.83, which is considered high when compared to a similar study area in Rommaninart park (with an area of 4.8 ha), Bangkok Thailand (2.29 species/ha) (Chaiyarat et al. 2019). The number reported in other parks of the world was 4.29 species/ha in AP park, Selangor, Malaysia (Jasmani et al. 2017), 2.02 species/ha in Don Juan Tenorio park, Salamanca, Spain (Peris and Montelongo 2014), and between 3.91-5.04 species/ha in Jiangsu province, China (Yang et al. 2020). A higher number of species reported in this study might be due to the design of the park with many microhabitats and multiple functions to serve both humans and avifauna while maintaining biodiversity. The difference in density could be due to the structure, the number of microhabitats, and plant species in the two parks. Plant species in the CU 100 park were chosen so as to provide microhabitats and foraging areas for birds, such as open lawns, grasslands, and shrubs with various species and structures. Careful selection of native and nonnative plant species can attract diverse bird species, benefiting the birds in terms of providing food sources such as insects residing on leaves, branches, twigs, barks of a tree trunk or underneath the bark, and nesting between branches, hanging on the canopy, or inside cavities of a tree trunk.

Even if the diversity of bird species in urban areas is lower compared to the natural habitat (Siri et al. 2019), the functional diversity as dietary guilds is not different (Lee et al. 2021), which was also observed in the CU 100 park, where all the bird dietary guilds were recorded including granivores, nectarivores, frugivores, omnivores, insectivores, and carnivores. High tree cover increased the diversity of the insectivorous, omnivorous, and granivorous bird species within either the spatial scattered or aggregated trees (Villaseñor et al. 2021). Trees were the predominant microhabitat in the park as they are food sources with both the horizontal to vertical substrate structures having multiple usages, whereas lawns and grasslands are only related to horizontal substrate or have one-dimensional usages (Figure 2). Thus, the differences between feeding guilds may vary by virtue of foraging substrate and vertical structure due to tree coverage, tree height, and tree canopy density (Mason and French 2008; Paker et al. 2014; Siri et al. 2019). We report a similar finding that the number of bird species was the highest in the tree microhabitat (Figure 2). A group of nectarivores fed on the flower nectar of *Millingtonia hortensis*, which is a common urban tree planted in Bangkok, Thailand (Thaiutsa et al. 2008) and was consumed by Olive-backed Sunbird (*Cinnyris jugularis*). Given their long sharp bill, Purple Sunbird (*Cinnyris asiaticus*) is able to suck the nectar, whereas the Brown-throated Sunbird (*Anthreptes malacensis*), which has a short bill, can consume nectar from various trees of the *Gardenia* spp. Frugivores mostly fed on *Ficus* spp. and *Syzygium* spp. and included several bird species like Purple Sunbird (*Psilopogon haemacephalus*), Yellow-vented Bulbul (*Pycnonotus goiavier*), Streak-eared Bulbul (*Pycnonotus conradi*), Scarlet-backed Flowerpecker (*Dicaeum cruentatum*), and Red-whiskered Bulbul.

However, the richness of bird diversity in urban green spaces is likely to have both positive and negative effects on human well-being. Birds play a critical role in the functioning of an urban ecosystem (Seress and Liker 2015; Haaksma et al. 2022), such as pollinators (nectarivore; Olive-backed Sunbird, Purple Sunbird), seed dispensers (granivore; Eastern Spotted Dove (*Spilopelia chinensis*), Coppersmith Barbet*;* frugivore*;* Yellow-vented Bulbul, Red-whiskered Bulbul), and insect/pest predators (carnivore; Brown Shrike (*Lanius cristatus*); insectivore; Malaysian pied Fantail (*Rhipidura javanica*): omnivore*;* Oriental magpie robin). On the contrary, an extremely dense population of some species in cities can have negative effects on human health, economy, and food production. Haaksma et al. (2022) given that avian influenza affects all birds, particularly migratory birds (Lycett et al. 2019); parasites can be transferred from Rock pigeon (Al-Barwari and Saeed 2012); House sparrow can be infested by ticks (Roselli et al. 2022); and filth (Eurasian tree sparrow, Eastern jungle crow, Rock pigeon, White-vened Myna, etc.). When compared to forest birds, urban birds showed more investigative behavior, antagonism, and a faster breathing rate (Caizergues et al. 2022), including different behavior due to variations in food and preferences (Tryjanowski et al. 2011; Lowry et al. 2012). In Thailand, most granivores (Eurasian tree sparrow, Eastern Spotted Dove, Scaly-breasted Munia, Zebra dove, etc.) are trending to change their feeding behaviors to take advantage of free feeding from the humans by staying close to them, etc. This might cause these birds to lose their instinct to search for food and to protect themselves.

In conclusion, the design of the CU 100 park was to mitigate and prevent future inland flooding due to climate change. The value of supporting services as the bird habitat in the park as was estimated at USD60,354.12. Asian Openbill, Painted Stork, and Chinese Pond Heron provided the greatest value, as indicated by the high value of each species. However, only the bird species were estimated in this study, while other animal species such as insects, amphibians, and fish were not included, which would further increase the value of the park. In addition, the monetary value of other supporting services such as biomass production, production of atmospheric oxygen, soil formation, retention, nutrient cycling, and water cycling should be estimated in a future study. We conclude that in order to attract birds and/or other animals, food sources along with safe and secure microhabitats would be necessary. For example, the water bodies will attract birds that feed on aqua animals such as fish and shells. While trees with crown cover and thick branches and leaves are good for birds that consume fruits, nectar, insects, apart from providing places to build safe nests; open areas with a cover of shrubs, brushes, short and long grass would attract species that eating grain and seeds. The results can be useful for city planners while designing urban parks to maintain the environment and its biodiversity, for human well-being, and avifauna species on a local scale. In addition, the management approaches for bird conservation in small areas could help to increasing the area under tree canopy as well as encourage wildlife friendly microhabitats and to drive public interest in local bird species to advance their successful conservation in a residential landscape.

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