REGULAR ARTICLE

PLANNING AND DESIGN CONSIDERATIONS FOR BIRDS AND BUTTERFLIES´ DIVERSITY OF SMALL URBAN PARKS: A CASE OF PETALING JAYA, MALAYSIA

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ABSTRACT

While most previous research has been conducted in large urban parks, the potential of small parks as urban habitats remains largely unexplored, particularly in tropical regions. The purpose of this paper is to provide landscape architects, planners, park managers and municipalities with recommendations for planning, design and management with the aim to enhance small urban parks' biodiversity. Physical characteristics, vegetation and human factors are the important features that were highlighted using empirical data from nine small urban parks in Petaling Jaya, Malaysia sized between 0.5-3.5 hectares. Birds and butterflies are used as ecological indicators because they are relatively easy to identify and show clear responses to environmental change. Pearson's correlations and multiple regressions, followed by an analysis of the Akaike's Information Criterion were conducted to study the relationships between the measured variables, and to identify which of the variables have a significant effect on bird and butterfly species richness and abundance. The results demonstrate that the percentage of canopy cover, park size and native vegetation are the best predictors of bird species richness and abundance. Meanwhile, the butterfly species richness and abundance can be best predicted by the percentage of canopy cover, shrub species and native vegetation. Based on these results and the identification of key features for bird and butterfly richness and abundance, nine recommendations are provided to improve biodiversity of small urban parks: (1) set minimum areas for a small urban park; 2) inclusion of water elements to support a wider range of species; (3) the application of internal patch-corridor-matrix features; (4) attention to the aspect of cleanliness and appearance of small parks; (5) the proportion of open and shaded areas; (6) the planting composition of trees, palms and shrubs should be designed not only with aesthetic functions, but also for biodiversity; (7) the vertical and horizontal layers of vegetation structures; (8) providing natural buffers for wildlife protection; and (9) creating unmanaged patches in sunny areas by using wildflowers.

Keywords: *ecological resilience; ecological design; urban parks; urban wildlife*

1. INTRODUCTION

In the face of increasing urbanisation, urban green spaces in cities may become smaller and more fragmented due to the demands for new infrastructure, housing development and other facilities for urban citizens. The provision of urban green spaces such as parks and gardens is important as they provide ecosystem services that are essential for the wellbeing of urban dwellers (Chiesura, 2004; Konijnendijk et al., 2013). When cities become more compact, designing and establishing large parks may be impossible. Therefore, municipalities, urban planners, and landscape designers have to turn to small green spaces as alternatives. In light of the small size of the green spaces, design and management considerations for these areas are often focused on social aspects and rarely integrate ecological considerations (Forsyth & Musacchio, 2005). Although the primary function of small parks in cities is to provide spaces for outdoor activities for urban dwellers, their potential for contributing to ecological connections and functions has been far less acknowledged. Previous studies suggest that small urban green spaces have a low biodiversity and ecological value compared to large ones (Donnelly & Marzluff, 2004; Fernandez-Juricic & Jokimaki, 2001; Oliver et al., 2011). However, in the absence of large urban parks, the existence of small parks can be particularly important to support both social and ecological functions. Small urban parks have much to offer and they not only contribute to neighbourhood recreation opportunities, but they are also valuable ecological resources; if small urban parks exist in substantial numbers, they can be designed as part of a green city network that forms an important part of a region's ecology (Ikin et al., 2013; Strohbach et al., 2013).

Small parks may be considered spaces which cover a limited area and which provide recreational benefits (Forsyth & Musacchio, 2005). In an urban context, some scholars have described small parks as pocket parks that consist of both grey spaces (such as paved areas and small squares) and green elements (trees, lawn, shrubs) (Nordh et al., 2009, 2011; Nordh & Østby, 2013; Peschardt et al., 2012) Different scholars have applied different size limits in their respective definitions of what constitutes a small urban park and a pocket park; for example, 1.0- 3.0 hectares is mentioned by Sibley et al. (2004); 2.0- 2.4 hectares by Forsyth and Musacchio (2005); < 5000m^2 by Peschardt et al. (2012); < 3000m^2 by Nordh and Østby (2013) and 0.5-2.0 hectares by Shwartz et al. (2013). Since there is no fixed definition, thus the present study defines small urban park as a small-scale urban green space (between 0.5 and 3.5 hectares in size), with distinctive boundaries, that provides opportunities for public recreation. In order to be considered a small urban park, an area should also have an important element of greenery (e.g. trees, lawn, shrubs) and be located in an urban area.

Design considerations for small urban parks aimed at increasing their values for ecology and biodiversity have rarely been discussed. Guidelines are not easily provided in the face of current knowledge constraints on what values can be achieved in such small urban parks. The main challenge for small urban parks to function as important components of ecological and biodiversity networks is that design plans are usually very specific in focusing on human perceptions and the visual aesthetic characteristics, rather than on ecological values and functions (Quigley, 2011). In tropical regions, particularly in Southeast Asia, even less attention has been given to the study of biodiversity in urban green spaces. Moreover, design solutions and management suggestions for enhancing urban biodiversity on different landscape scales are scarce (Ignatieva, 2010; Müller et al., 2013; Sing et al., 2016).

The purpose of this paper is to provide landscape architects, landscape and urban planners, park managers and municipalities with recommendations for park planning, design, and management, with the aim of enhancing the biodiversity and ecological qualities of small urban parks. The present paper highlights important features of small urban parks that contribute to their ecological qualities, and which may directly support biodiversity, based on empirical evidence from case study sites in Peninsular Malaysia. The goal is to raise awareness amongst practitioners on the importance of small urban parks, as well as of urban landscape design and ecological conservation. Small urban parks should be promoted as places for people to connect with nature, while also maximising their potential as biodiversity refuges in urban environments.

1.1 Ecological resilience as central concept for small urban park design and management

In framing small urban parks as part of the green network system in cities, the use of the broader concept of 'resilience' is perhaps too complex and too difficult to apply for urban designers, landscape architects and park managers. Therefore, we suggest instead to use the more specific concept of 'ecological resilience', which is defined as the ability of an ecosystem to adapt to disturbance while maintaining its functions in the face of environmental change (Alberti & Marzluff, 2004). For small urban parks, applying the theory of ecological resilience in design and management could generate principles that are quite different from those conventionally used. In urban planning and design, the role of biodiversity in ecological resilience is substantial, but it has often received lower priority because the functions and services of biodiversity are not fully understood (Ahern, 2013). Understanding the role of urban biodiversity in achieving ecological resilience can be related to the context of functional diversity, i.e. related to the different groups of species that are represented in a system (e.g. trees, shrubs, birds, or insects), and to response diversity, i.e. the range of different responses to environmental change within species groups (M. Hunter, 2011; Walker & Salt, 2006).

In reality, small parks in cities may not be as biodiverse as large urban parks, but there is potential for design modification and management strategies that enhance habitats for generalist species (Forsyth & Musacchio, 2005). Small urban parks can be created and managed not only for their social functions but also to serve as refuges for wildlife. Moreover, social and ecological values are linked, as experiencing nature in small parks can be restorative if fascinating elements (e.g. related to richness of species) are present (Nordh et al., 2009). Therefore, enhancing biodiversity in small parks can be an added value to the fascination. However, it might be unclear as to whether the characteristics of a small urban park that are attractive to humans are likewise able to attract urban wildlife.

1.2 Why focus on birds and butterflies in small urban parks?

Exposure to wildlife-rich green spaces and appreciation of biodiversity may contribute to human psychological and physiological well-being (Fuller et al., 2007). Birds and butterflies are among the most appreciated wildlife in urban green spaces because they are visually appealing, and urban citizens expect their presence (Luck et al., 2011; Sandifer et al., 2015). Birds can play a vital role in our urban ecosystems, for examples as pollinators, pest control or seed dispersers (Whelan et al., 2008). Unfortunately, some bird species are also considered as pests due to their disturbing behaviour, as in the case of *Corvus splendens* (House Crow) and *Acridotheres tristis* (Common Myna) (Sodhi et al., 2011). Meanwhile, butterflies, apart from their beautiful and pleasing appearance, also function as pollinators, and as caterpillars, they themselves are food for other organisms (Ghazanfar & Raza, 2015). Butterflies have unique short lifecycles, and their survival is dependent on the resources available within microhabitats. Therefore, the presence of butterflies in urban green spaces can be an indicator of a healthy habitat (Josephitis, 2014). Birds and butterflies are both useful ecological indicators as both taxa are highly similar in their response to environmental change and disturbance (Blair, 1999).

2. METHODS

2.1 Study sites

The study was conducted in the city of Petaling Jaya, Selangor, Malaysia and nine small urban parks were investigated. Figure 1 shows the location of the nine small parks within the city and their individual size, listed from the smallest to the largest. All nine selected parks in this study are managed by the Petaling Jaya City Council (PJCC). The parks were selected based on the criteria that meet the definition of small urban parks.

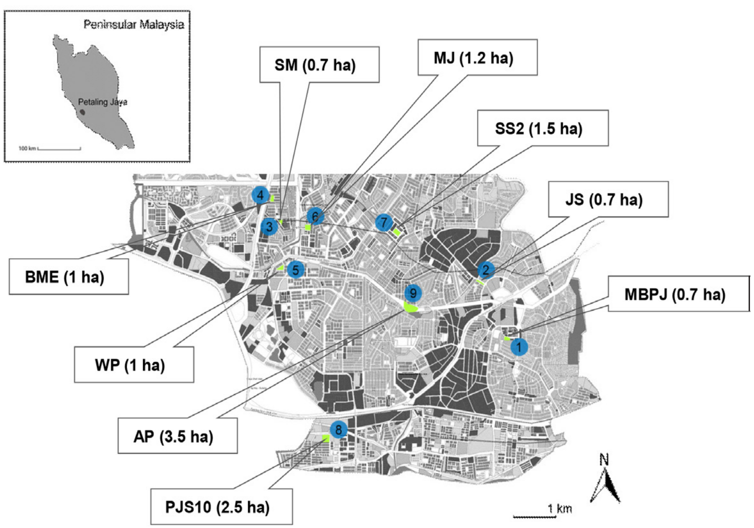

Figure 1: *The location of studied parks in Petaling Jaya, Malaysia including Jalan Semangat (JS), Sunway Mas (SM), Bukit Mayang Emas (BME), Wawasan Park (WP), Mayang Jaya (MJ), and Aman Park (AP). All other abbreviations are the actual names of the parks.*

2.2 Identifying and measuring social and ecological variables

In this study, structured observations and field measurements were combined as the methods for data collection. Research framework based on Jasmani et al., (2015) was developed to examine the characteristics of social and ecological aspects of small urban parks. Data is grouped into two main categories in the framework, namely *ecological* and *anthropogenic* (human-related action). Observations in the parks were carried out for three consecutive working days for two hours each in the morning (7.30 am to 9.30 am), afternoon (12.30 pm to 2.30 pm) and evening (5.00pm to 7.00 pm). The observations in each park were done by two or three observers simultaneously during a given period. Using the framework in Jasmani et al. (2015), the variables measured were divided into three data sets: *physical characteristics, species richness* and *human factors*. The variables and sub-variables consist of quantitative and qualitative data of the social and ecological components of small parks.

2.3 Bird and butterfly surveys

Bird and butterfly sightings were recorded three times a day as mentioned earlier. For bird observations, 40 to 50 m radius point counts (three points in each park) were used (Carbó-Ramírez & Zuria, 2011). The details on the bird observation method can be referred in Jasmani et al.(2016). Birds species seen within the radius were recorded and identified. Birds that were only flying overhead were ignored. Meanwhile, butterflies were identified using the transect walk method (Kadlec et al., 2012), in which any butterflies observed within a 15 m width while walking along selected routes in the park were recorded. In order to identify as many of the birds and butterflies in the parks as possible, the time survey method was also used in which observers searched through the park, especially in areas of dense vegetation and containing suitable habitats for the various identified species (Kadlec et al., 2012). Since the studied parks were relatively small, both transect walk and timed survey allow for detecting numbers of butterfly species and abundance. Photographs of the observed birds and butterflies were taken with a high-resolution digital camera, and species were identified using Davison and Aik (2010) and Kirton (2014). Species abundance was recorded based on a rating scale value between 1 (very low) to 10 (very high). The scale values were used to estimate the frequency of the species presence in the parks.

2.4 Data analysis

This study used mixed methods to explain and compare quantitative results with qualitative findings (Creswell, 2014). All data from the field survey was first processed in Microsoft Excel using the pivot function to build a variables matrix. Land use maps and satellite images were utilised for analysing the spatial characteristics and configuration of vegetation cover. The diversity of vegetation, birds and butterflies were calculated based on the Shannon-Weiner

Diversity Index *(H)* formula (Cornelis & Hermy, 2004; Krebs, 1999). In order to identify the relationships between the measured variables with bird and butterfly richness and abundance, the Pearson's correlation analysis was performed, followed by multiple linear regressions. Subsequently, the elaboration of the Akaike's Information Criterion was carried out, corrected for small sample size (AICc) (Burnham & Anderson, 2002; Oliver et al., 2011), in order to analyse and determine which of the variables were significantly influencing the presence and absence of birds and butterflies in the small parks. Multiple regressions (2-3 predictors) were performed for each variable, namely bird species richness, bird abundance, butterfly species richness and butterfly abundance.

3. RESULTS

Presence of birds and butterflies in small parks: A total of 22 bird species and 23 butterfly species were recorded in the nine parks. Birds found in the parks were mostly insectivores and omnivores, and butterflies were mostly from the families of Nymphalidae and Pieridae. The highest Shannon-Weiner Diversity Index for birds was recorded in PJS10 (H= 2.73), and butterfly diversity was found to be highest in MJ (H= 2.54). Observations has recorded that the presence of birds was higher in the morning and afternoon and less birds were seen in the evening. Meanwhile, butterflies were presence when the weather was hot and sunny. The most abundant bird species was *Passer montanus* (Eurasian Tree-sparrow), followed by *Copsychus saularis* (Oriental Magpie-robin) and *Corvus splendens* (House Crow). *Hympolimnas bolina* (Great Egg-fly) was the most abundant butterfly species recorded, followed by *Eurema hecabe* (Common Grass Yellow) and *Appias libythea* (Striped Albatross). Most of the birds and butterflies found are common in urban green areas in Malaysia, and they can be regarded as generalist species and urban adapters. Also observed was the presence of passage migrant bird *Merops viridis* (Blue-throated Bee-eater) and waterbird *Butorides striata* (Little Heron) in PJS10 and AP. The bird of prey *Accipiter trivirgatus* (Crested Goshawk) was seen roosting on the branches with dense foliage. The presence of forest butterfly species *Curetis santana* (Malayan Sunbeam) and *Lyssa zampa* (Tropical Swallowtail Moth or sometimes called Laos Brown Butterfly), a large, conspicuous moth species that resembles butterflies, were also noted.

Small park physical characteristics: The topography of the studied parks is mostly flat, except for AP which has a rather undulating landscape. There are several similarities and differences in park characteristics. All parks are easily accessed by pedestrians and all are equipped with facilities for outdoor recreation. Based on the observations, it was noted that the complexity of park layout and features varied depending on the location and purpose of the small parks. Parks that are located in important areas in the city centre or within higher income residential areas received intensive care and higher maintenance, for example in terms of mowing or pruning (i.e. MBPJ, PJS10 and AP). The noise level is higher in parks that are located next to a busy road (especially during peak hours) such as in MBPJ and JS. Parks featuring an open lake (PJS10 and AP) have a higher complexity in hardscape and softscape components.

Vegetation diversity and structure: A total of 89 different plant species (trees, palms and shrubs) were recorded. In general, similarities were found in plant species across all small parks, which might be due to the landscaping guidelines provided by the municipality. The most popular tree species used for ornamental purposes is *Tabebuia rosea* (Trumpet Tree), while *Veitchia merrilli* (Christmas Palm) is the most common palm species planted. Meanwhile, *Hymenocallis speciosa* 'Variegata' (Spider Lily) is frequently used as an ornamental shrub. From the vegetation matrix it could be discerned that more exotic vegetation was planted than native. The trend of using exotic species as ornamental plants in small parks is perhaps due to the prevailing floral aesthetic. In MBPJ, the planting of flowering shrubs is higher compared to other parks, and it exhibits the highest use of exotic plants.

Human-related activities in the parks and their surroundings: The observation of user activities demonstrated that 42% of the activities in the parks were utilitarian (e.g. walking or motorcycle access to other areas), 32% related to recreation (e.g. relaxing or family outings), and the remaining of the activities (26%) were related to sports, play and special occasions. The highest number of visitors per day was recorded in JS with 514 visitors, and the lowest was in WP with only 81 visitors during the observation periods. Pertaining to auditory aspects, more anthropogenic sounds were experienced (e.g. traffic noise, passing aeroplanes and trains, human shouting) than natural sounds (e.g. bird chirping, wind rustling in the trees, etc.). In addition, more unpleasant than pleasant smells were experienced, with the former originating from vehicles, animal manure, food waste, garbage and drains.

Analysis of bird and butterfly species richness and abundance: Table 1 presents the results of the Pearson's correlation with gradient scales, showing the association of variables measured with bird and butterfly species richness and abundance. The greener the value, the stronger the positive correlation, while values associated with a red gradient indicate negative correlations. The percentage of canopy cover has a strong negative correlation with bird species richness (r = -0.692) and abundance (r = -0.803), while being positively correlated with butterfly richness (r = 0.781) and abundance (r = 0.646). Whereas the percentage of open grass/ground has a positive correlation to birds (r = 0.674 and r = 0.793) but not to butterflies (r = -0.771 and r = -0.641). Total vegetation, native vegetation, total flowering plants, shrubs species and the number of flowering shrubs were strongly correlated with butterfly abundance. Recreational activities have a strong positive correlation with bird species richness and abundance, while utilitarian human uses were found to be negatively correlated, although the Pearson's correlation results indicate that the effect was minimal.

Table 1 : Pearson's correlations (r) with gradient scales to illustrate the association between the measured variables with bird and butterfly richness and abundance.

Variables	Bird species richness	Bird abundance	Butterfly species richness	Butterfly abundance
Bird species richness	1	0.930	-0.321	-0.037
Bird abundance	0.930	1	-0.541	-0.210
Butterfly species richness	-0.321	-0.541	1	0.878
Butterfly abundance	-0.037	-0.210	0.878	1
Area (hectare)	0.513	0.453	0.102	0.485
Perimeter	0.396	0.397	0.027	0.413
Canopy covers (%)	-0.692**	-0.803***	0.781***	0.646*
Total vegetation	0.313	0.191	0.501	0.671**
Open grass/ ground (%)	0.674**	0.793***	-0.771**	-0.641*
Overall vegetation species	0.361	0.317	0.305	0.586*
Exotic vegetation species	0.340	0.246	0.419	0.583*
Native vegetation species	0.338	0.347	0.182	0.536
Native vegetation (NOI)	0.387	0.318	0.382	0.714**
Exotic vegetation (NOI)	0.207	0.047	0.550	0.552
Total flowering plants	0.128	0.062	0.547	0.718**
Number of trees	0.241	0.303	0.125	0.502
Tree species	0.358	0.379	0.097	0.432
Large woody trees	-0.080	0.061	0.091	0.401
Number of shrubs	0.267	0.090	0.541	0.572
Shrubs species	0.290	0.112	0.608*	0.713**
Number of flowering shrubs	0.102	-0.036	0.618*	0.643*
Number of palms	0.263	0.189	0.402	0.583*
Palm species	0.274	0.267	0.274	0.531
Mean canopy size (m)	-0.540	-0.585*	0.158	-0.108
Mean tree height (m)	-0.558	-0.557	0.116	-0.054
Mean tree diameter (DBH)	0.064	-0.080	0.051	0.094
Mean shrubs height (m)	0.472	0.612*	-0.514	-0.486
Mean number of park visitors	0.028	-0.075	0.049	0.249
Mean noise levels (dB)	-0.137	-0.190	0.006	-0.007
Utilitarian	-0.155	-0.182	-0.098	0.037
Recreation	0.626*	0.625*	-0.192	0.236
Sports	0.427	0.497	-0.160	0.155
Play	0.319	0.442	-0.300	-0.079
Special occasion	0.362	0.391	-0.199	-0.093

Gradient scales

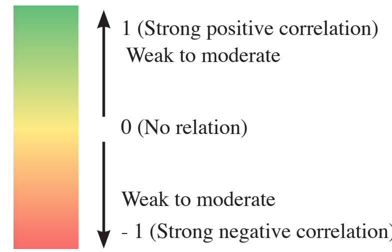

Table 2 shows the results of multiple linear regression analyses followed by Akaike's Information Criterion corrected for a small sample. Forty-two selected regression models are presented for both birds and butterflies based on the Adjusted $R^2 \geq 0.5$ and P-value < 0.1 (Confidence Interval 90%). Taking into account the smallest AICs as the basis for selecting the best predictor variables, the regressions indicate that the percentage of canopy cover (negative relation) and park area (positive relation) significantly influences bird species richness (Table 2, model A2). For bird abundance, the percentage of canopy cover (negative relation) and native vegetation species (positive relation) are the best predictors (Table 2, model B3). For butterflies, the best predictors of species richness were the percentage of canopy cover (positive relation) and shrub species (positive relation) (Table 2, model C1). The best predictors for butterfly abundance were the percentage of canopy cover (positive relation) and the number of native vegetation (positive relation) (Table 2, model D1).

However, only a few of the other predictor variables were also correlated significantly with birds and butterflies, whereas in the regression analyses, not all of the individual predictor were included to test their significance. Moreover, only quantitative variables were considered thus far. Therefore, to visualise the relationship of both quantitative and qualitative predictor variables with bird and butterflies, a relational matrix was developed, which explicitly shows the significance of all predictor variables measured in the research (Table 3). Table 3 presents the overall summary of the findings of the correlation and regression analyses, with the purpose of simplifying the study's statistical findings in an understandable way for design and management practice. In the next section, the study findings are discussed with the specific purpose of relating the empirical results to the planning, design and management of small urban parks.

Table 2 : Results of model selection and regression analysis of bird and butterfly species richness and abundance. Models were tested with different combination of predictor variables. Only models which explained at least 50% (Adjusted R2 > 0.5) of the variation with P-value <0.1 are shown here (confidence interval at 90%). AICc is the Akakike's Information Criterion for small sample size and ∆AICc is the difference in AICc between each model and the model with the smallest AICc.

Model ID	Bird species richness models	Adjusted R2	P-value	AICc	∆AICc
A1	Canopy cover + Mean tree height +Mean tree DBH	0.724	0.023	27.685	4.359
A2	Canopy cover +Area	0.684	0.013	**23.326**	0
A3	Open grass/ ground +Shrub species + Flowering shrubs	0.63	0.048	30.315	6.989
A4	Canopy cover + Native vegetation (NOI) + Large woody trees	0.615	0.053	30.677	7.351
A5	Utilitarian +Recreation + Sport	0.611	0.054	30.771	7.445
A6	Canopy cover + Total vegetation	0.546	0.039	26.595	3.269
A7	Native vegetation (NOI) + Mean shrub height	0.467	0.064	28.033	4.677
Model ID	**Bird abundance models**	**Adjusted R2**	**P-value**	**AICc**	**∆AICc**
B1	Total vegetation + Canopy cover + Exotic vegetation	0.802	0.01	51.698	5.352
B2	Canopy cover + Exotic vegetation (NOI) + Area	0.80	0.01	51.802	5.456
B3	Canopy cover + Native vegetation species	0.798	0.003	**46.346**	0
B4	Canopy cover + Overall vegetation species	0.756	0.006	48.043	1.697
B5	Open grass/ ground + Tree species	0.756	0.006	47.974	1.628
B6	Canopy cover + Number of trees	0.742	0.007	48.521	2.175
B7	Mean tree height + Mean shrub height + Area	0.702	0.028	55.383	9.037
B8	Native vegetation species + Mean shrub height	0.488	0.057	54.703	8.357
B9	Utilitarian + Recreation + Sport	0.483	0.1	60.349	14.003
Model ID	**Butterfly species richness models**	**Adjusted R2**	**P-value**	**AICc**	**∆AICc**
C1	Canopy cover + Shrub species	0.757	0.006	**18.321**	0
C2	Canopy cover + Number of shrubs	0.749	0.007	18.630	0.309
C3	Canopy cover + Exotic vegetation (NOI)	0.746	0.007	18.730	0.410
C4	Open grass/ground + Shrub species	0.745	0.007	18.752	0.431
C5	Open grass/ground + Number of shrubs	0.74	0.007	18.949	0.628
C6	Canopy cover + Flowering shrubs	0.692	0.012	20.453	2.132
C7	Canopy cover + Total vegetation	0.677	0.014	20.887	2.567
C8	Total flowering plants + Open grass/ground	0.599	0.027	22.831	4.510
C9	Canopy cover + Native vegetation (NOI)	0.579	0.031	23.274	4.953
C10	Overall vegetation species + Open grass/ ground	0.518	0.047	24.497	6.176
C11	Open grass/ ground + Area	0.463	0.066	25.474	7.153
C12	Open grass/ ground + Tree species	0.462	0.066	25.491	7.170
Model ID	**Butterfly abundance models**	**Adjusted R2**	**P-value**	**AICc**	**∆AICc**
D1	Canopy cover + Native vegetation (NOI)	0.748	0.007	**40.31119**	0
D2	Open grass/ ground + Shrub species	0.689	0.013	42.22006	1.909
D3	Canopy cover + Shrub species	0.689	0.013	42.22065	1.909
D4	Total vegetation + Canopy cover	0.668	0.015	42.80976	2.499
D5	Total flowering plants + Canopy cover	0.612	0.025	44.20237	3.891
D6	Canopy cover + Exotic vegetation species	0.593	0.028	44.63478	4.324
D7	Canopy cover + Palm species	0.568	0.034	45.18527	4.874
D8	Canopy cover + Number of palms	0.565	0.035	45.24763	4.936
D9	Overall vegetation species + Open grass/ ground	0.56	0.036	45.339	5.028
D10	Canopy cover + Number of shrubs	0.551	0.038	45.51953	5.208
D11	Open grass/ ground + Exotic vegetation (NOI)	0.514	0.048	46.23098	5.920
D12	Canopy cover + Native vegetation species	0.503	0.052	46.43689	6.126
D13	Open grass/ ground + Area	0.477	0.06	46.89512	6.584
D14	Canopy cover + Number of trees	0.466	0.064	47.08193	6.771

Table 3 : Relation matrix of birds and butterflies with the variables measured in the studied parks. The relation summary for species richness and abundance for birds and butterflies were based on the Pearson's correlation and regression analysis results. Some of the results are also based on observations during the field survey.

Variables	Birds		Butterflies	
	Species richness	Species abundance	Species richness	Species abundance
Physical characteristics				
Area (hectare)	+ **	+ **	+ ø	+ ø
Presence of water bodies	+ obs.	+ obs.	x obs.	x obs.
Proximity to road traffic and buildings	– obs.	– obs.	x obs.	x obs.
Cleanliness	– obs.	– obs.	x obs.	x obs.
Surrounding land use	– obs.	– obs.	x obs.	x obs.
Shape of the park	x obs.	x obs.	x obs.	x obs.
Vegetation structure				
Total vegetation	+ ø	+ ø	+ ø	+ **
Overall vegetation species	+ ø	+ *	+ ø	+ *
Total flowering plants	x	x	+ ø	+ **
Canopy covers (%)	– **	– ***	+ ***	+ **
Open grass/ ground (%)	+ **	+ ***	– ***	– **
Vegetation composition	+ obs.	+ obs.	+ obs.	+ obs.
Trees				
Species	+ ø	+ **	x	+ ø
Total number of trees	+ ø	+ *	x	+ ø
Large woody trees	x	x	x	+ ø
Mean tree canopy size (m)	– ø	– ø	x	x
Mean tree height (m)	– *	– ø	x	x
Mean tree diameter	+ *	– ø	x	x
Shrubs				
Species	+ *	+ ø	+ **	+ **
Total number of shrubs	+ ø	x	+ **	+ *
Number of flowering shrubs	+ ø	x	+ *	+ ø
Mean shrub height (m)	+ **	+ **	– ø	– ø
Palms				
Species	+ ø	+ ø	+ ø	+ *
Total number of palms	+ ø	+ ø	+ ø	+ *
Native vegetation				
Species	+ ø	+ **	+ ø	+ ø
Total number of native vegetation	+ **	+ ø	+ ø	+ ***
Exotic vegetation				
Species	+ ø	+ ø	+ ø	+ *
Total number of exotic vegetation	+ ø	– *	+ **	+ ø
Human factors				
Mean number of park visitor (/day)	x	x	x	x
Mean noise levels (dB/day)	– ø	– ø	x	x
Maintenance & management practice	+ obs.	+ obs.	+ obs.	+ obs.
Activities				
Utilitarian	– **	–*	x	x
Recreation	+ **	+**	x	x
Sports	– *	–*	x	x

Note: *Meaning of the relation code;*

+ Positive relation	*** Highly significant; p value < 0.01
– Negative relation	** Significant at p value < 0.05
x No relation	* Significant at p value < 0.1
obs. Based on observation	ø not significant

4. DISCUSSION AND RECOMMENDATIONS

4.1 Park physical features and characteristics

Although the design layout and physical appearance of small urban parks can vary, limitations are typically encountered due to the size and available natural resources. The results demonstrate that increased park size may also increase bird species richness and abundance, but this is not necessarily the case for butterflies (see Table 3). Findings on the positive relation of park area to birds support earlier work by Kang et al. (2015). Although park area shows a positive association (weak) with butterflies, this was not significant, which is in line with the previous study by Lizee et al. (2015). In relation to water elements, it was found that small parks that have natural water bodies have an advantage in attracting water birds. Butterflies were not dependent on open water (Chamberlain et al., 2007; Yücel, 2013).

The influence of activities from the surrounding land uses, and the aspect of cleanliness may also determine the presence and absence of bird species. During observations at SS2, for example, it was found that the park functioned actively as an eating area for visitors due to its location at the centre of the commercial area, and close to restaurants and open food courts. Consequently, the park was frequently visited by house crows (*Corvus splendens*) feeding on the food scraps. These house crows are a nuisance with their loud cawing and their behaviour of scattering rubbish in the park. When the food courts were operating, the number of crows increased while the presence of other bird species was low. Only at the area where medium-height trees were present in clumps, a few other bird species observed, such as Pied Fantail (*Rhipidura javanica*) and Olive-backed Sunbird (*Cinnyris jugularis*). The presence of abundant house crows may pose a threat to small birds through nest predation or resource competition (Chace & Walsh, 2006; Francis & Chadwick, 2013; Jokimäki, 1999). While the presence of birds is influenced by the surrounding activities, butterflies were not affected by these.

Recommendation 1 (R1): The planning of new small urban parks has to set a minimum area to promote their ecological functioning. Small parks should not only focus on social needs but also incorporate ecology and biodiversity goals. Since the area for new small parks and existing ones can be limited, the overall layout and spatial configuration of the parks should target the improvement of internal habitat quality.

Recommendation 2 (R2): Patch-corridor-matrix features should be applied to enhance internal habitat quality of small parks. Internal patch-corridor-matrix features could function as protection zones (e.g., from traffic volume, predators) as well as provide habitat variability for urban birds and butterflies

Recommendation 3 (R3): Wherever possible, the inclusion of natural water bodies is highly recommended, for example in the shape of a small pond or lake to encourage a greater diversity of bird species.

Recommendation 4 (R4): Attention should be given to the aspects of cleanliness and appearance of small parks. It is important to provide rubbish bins with lids so that trash containing food scraps can be disposed of appropriately, thus minimising the attraction of scavenging fauna.

4.2 Vegetation diversity and structures

The percentage of canopy cover has a significant negative relationship to birds, while on the other hand, it was found to be positively correlated with butterflies. In contrast, the percentage of open grass or open ground was found to have a significant positive relationship to bird abundance and diversity, while negatively impacting butterflies. Many of the bird species recorded in this study are related to open country and they inhabit forest edges. Thus they require habitat that has open areas with grasses, scrubland and varied vegetation structures (Rajpar & Zakaria, 2015; Ramli et al., 2012). Although canopy trees can provide shade and cooling, too much closed-canopy from trees without understory vegetation may have an impact to the biodiversity. For example, findings in MJ indicate that although the park has many large tall trees (of more than 10 m height) which contribute to the highest percentage of canopy cover (90%), bird diversity is also the lowest of among all the parks. This might be due to a lack of shrub layers and large plantings of the same tree species (low species diversity). Butterflies require sunny areas for basking and becoming active (Yücel, 2013), yet the study results contradict this. Findings can be related to the proportion and composition of vegetation as well as predation risk. Since most birds found in the studied parks are insectivores and omnivores, there is a higher possibility that those birds were foraging for larvae (caterpillar) or adult butterflies, which reinforces the negative correlation between birds and butterflies.

For many parks in cities, most vegetation is cultivated and managed intensively for user convenience and aesthetic purposes. People's perception towards unmanaged or 'wild looking' vegetation has often been negative, and this type of vegetation has been perceived as ugly (Qiu et al., 2013). However, such vegetation has a significant positive influence on biodiversity (Shwartz et al., 2013). The term 'unmanaged' suggests allowing an area of vegetation to grow naturally within the parks. Incorporating unmanaged patches within small parks could be a good strategy for encouraging more biodiversity. However, taking into account the climatic conditions of tropical countries, unmanaged vegetation may cause environmental and social conflicts, as unmanaged vegetation can become a breeding ground for mosquitoes (Sing et al., 2016) and create a sense of fear and unsafety (Maruthaveeran & van den Bosch, 2014). Notwithstanding, small urban parks may have some advantages compared to larger ones, as settings for unmanaged vegetation can be controlled more easily due to the small area. Feelings of fear might be less because of higher visibility and surveillance, for example from nearby road and buildings.

The planting of exotic species in urban parks was introduced to Malaysia in the 18th century during the British colonial era. Among the popular exotic species planted are *Bougainvillea spp*. (Bougainvilleas), *Swietenia macrophylla* (Mahogany), *Samanea saman* (Rain Tree), *Delonix regia* (Flame of the Forest) and *Pterocarpus indicus* (Angsana) (Mohd Shariff & Bakar, 2006; Sreetheran et al., 2006). Other introduced plant species such as *Hibiscus rosa-sinensis* (Chinese Hibiscus) and *Lantana camara* (Lantana) are popular as garden plants due to their attractive flowers. Although these introduced species are non-native to Malaysia, they have a long history of adaptation and have become widespread as ornamental plants and 'naturalised' to the local environment. Plants that produce fruit attract frugivorous and insectivorous birds. In SM, for example, fruits from a row of *Ficus benghalensis* (Indian Banyan) were eaten by several bird species such as *Treron vernans* (Pink-necked Green Pigeon), *Aplonis panayensis* (Asian Glossy Starling) and *Orthotomus sutorius* (Common Tailorbird). Meanwhile, plants that also produce nectar such as *Syzygium myrtifolium* (Kelat Paya or Australian Brush-Cherry) also favour birds and butterflies. Although planting fruit trees in small parks is beneficial to wildlife, a cleanliness issue may occur if the ripe fruits are large and fall from the trees. This will require regular cleaning, otherwise rotten fruit may attract rodents, create a mess and bad smell, leading to potential conflicts between social and ecological values.

The results in Table 3 show that birds favoured tall shrubs compared to tall trees, while butterflies were influenced by the density and diversity of flowering shrubs species. The results suggest that tall woody trees are not necessarily important for urban wildlife in small parks because urban species can utilise medium trees and shrubs for their needs. Taller shrubs may provide dense foliage, food and habitat that is secure for shrub-nesting birds such as *Pycnonotus goiavier* (Yellow-vented Bulbul) (Imai & Nakashizuka, 2010; Rousseau et al., 2015). The availability of caterpillar larvae host plant is fundamental for butterfly reproduction, and flowering shrubs that have potential as host plants and produce nectar will support more butterflies species (Lian & Sodhi, 2004). In addition, adult butterflies in the tropical region feed on a variety of fruits (Bonebrake et al., 2010).Therefore providing fruit-producing plants in small parks can be a good strategy for attracting more butterflies. Given the fact that small parks have a limited size, the available habitats may mostly be suitable for generalist species that are not sensitive to environmental disturbance (Forsyth & Musacchio, 2005). However, based on field survey evidence, small parks also offer opportunities for attracting some migratory bird species for foraging, which support a study by Carbó-Ramírez and Zuria, (2011).

Recommendation 5 (R5): Issues of proportion need to be considered for small urban parks in the light of their potential as ecological nodes using the approach of internal patch-corridor-matrix features (follow-up from R2): (a) The proportion of vegetated area and open grass/ground has to be balanced. Small parks should not be too shaded or too open so as to create a spatial hierarchy and transitions for urban species interactions (e.g., through sand bath for birds or puddles for butterflies). This can be achieved by creating vegetation patches and corridors with different species and structures; (b) Balancing proportions of managed and unmanaged vegetation provide opportunities for wildflowers to grow naturally in specific internal patches. Allowing spontaneous wildflowers to grow for a period of time can create semi-natural habitats for birds and butterflies. This strategy requires the designers or park managers to think creatively about how to manage wildflowers so that it is socially acceptable and pleasing to the park visitors. One idea is to create wildflower patches within the park; (c) appropriate mixtures of native and exotic vegetation are acceptable for small urban parks in order to maximise the diversity of birds and butterflies. Designers must choose exotic species wisely and should refrain from using these as major park components because they may become invasive and out-compete native species. Fruit bearing plants can attract more birds, but plants that produce smaller fruits are more suitable than larger ones.

Recommendation 6 (R6): The planting composition of trees, palms and shrubs in small urban parks should be designed not only for their aesthetic function but also for ecological benefits. Planting medium height trees in a row or in clumps rather than in solitary can enhance connectivity by providing an ecological corridor as well as shelter for various species (follow-up from R3).

Recommendation 7 (R7): Although small parks have a limited area, considering the vertical and horizontal layers of vegetation structure can maximise the opportunities for attracting birds and butterflies. This will also enhance vegetation transition and spatial heterogeneity (follow-up from R5 (a)). However, designers and managers must keep user safety aspects in mind when following this recommendation.

4.3 Protection and management practice

Human factors can either positively or negatively influence the ecological functioning and biodiversity of urban parks. The results of the present study revealed that human activities of a utilitarian nature may have adverse effects, while recreational activities have a positive influence on the presence of birds. Utilitarian uses involve active movements that can unintentionally disturb birds and their nesting sites (Campbell, 2006). The positive relationship of recreation and presence of birds is perhaps due to food opportunities. During the field survey it was observed that some people were purposely feeding birds e.g. with food leftovers.

The habitat quality for urban wildlife in small parks can be influenced by management and maintenance practices. Good management practices can help to protect or establish habitats, increase species diversity, improve vegetation composition and even reduce maintenance costs (Forsyth & Musacchio, 2005; Shwartz et al., 2013). Standard management practices in small parks include grass cutting, pruning and fertilising. Some urban parks also require insecticide application to control plant diseases and blood-feeding insect such as mosquitoes (Sing et al., 2016; Tam & Bonebrake, 2015). Mosquito attacks in urban parks can be problematic especially in tropical countries because, being vectors of disease causing parasites and viruses, they can cause severe health problems (Tomalak et al., 2011). The researchers themselves experienced intense frequency of mosquito bites during the field survey, especially at dawn and dusk. Managing small urban parks to increase biodiversity while at the same time satisfying social needs can create conflicts, for example in terms of the habitat maintenance (Forsyth & Musacchio, 2005). On the one hand, people prefer urban parks that are managed, with short grass, mowed lawns, colourful flowerbeds and nicely trimmed shrubs, while on the other hand increased biodiversity requires more unmanaged areas and 'natural settings' with some tall grass, wildflowers and diverse vegetation structures (Qiu et al., 2013). Although unmanaged habitats can be created by leaving some tall grass and wildflowers to grow within the small parks (Shwartz et al., 2013), this might not be a good idea to some people as unmanaged habitats can become breeding areas for mosquitoes (Sing et al., 2016), or be perceived as messy and less attractive. In the present study, mosquitoes were observed to be breeding in areas that are dark and damp, and where stagnant water are available, while in dry areas with direct exposure to sunlight, no mosquitoes were noticed. The use of insecticides might affect butterfly populations (Muratet & Fontaine, 2015), besides increasing maintenance costs.

Birds and butterflies react differently to mowing activities. In this study it was observed that during the mowing, granivorous birds such as *Geopelia striata* (Zebra Dove) and *Streptopelia chinensis* (Spotted Dove), and omnivorous birds, were taking advantage of the situation by feeding on seeds thrown up and scattered by the mower. In contrast, the presence of butterflies decreased after mowing, perhaps due the removal of wildflowers. In areas where flowering shrubs are not available, butterflies will depend on wildflowers for nectar. Among the species of wildflowers favoured by butterflies are *Tridax procumbens* (Coatbuttons) and *Bidens pilosa* (Spanish Needle). In fact, *Tridax procumbens* (Coatbuttons) is an excellent plant to repel mosquitoes (Rajkumar & Jebanesan, 2007).

Recommendation 8 (R8): In order to buffer potential disturbances from humans and provide shelter for wildlife, park designers may use a vegetation composition strategy (building on R5, R6 and R7). This type of strategy could enable urban wildlife species to coexist with people in smaller spaces.

Recommendation 9 (R9): When mowing, some tall grass should be left next to the short grass in patches, and wildflowers should sometimes be left to grow naturally. Unmanaged patches should be provided in areas with direct sunlight. Reducing the frequency of mowing would increase opportunities for the natural process of succession to take place. Moreover, this approach may also reduce maintenance cost. Furthermore, designers and park managers can make use of the wildflowers to create a sense of variety and 'rhythm' in tropical urban landscapes, rather than to stick to traditional landscape design (follow-up from R5 (b)).

5. CONCLUSION

This study has identified a series of key features of small urban parks' bird and butterfly species richness and abundance which later will enhance the biodiversity of the parks. The recommendations need public attachment and appreciation in maximising the biodiversity of the small urban parks (Hunter & Hunter, 2008). Each recommendation has different objectives that are linked together by combining different park physical features, vegetation, and management. This will benefit landscape architects, planners, and park managers in experiencing the ecological design of the parks. With smaller actions, if applied across large metropolitan areas, substantially support can be provided to wildlife resources and to creating linked and better functioning ecological systems. Further studies on other groups of wildlife such as mammals and amphibians should be explored to encourage the potential of small parks for urban biodiversity conservation. It is important to keep in mind that; biodiversity can be varied even in small urban parks. In short, small parks are often complementary and can provide solutions for biodiversity enhancement when cities become more densified and space for larger green spaces becomes limited.

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