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Temporal Changes in Diversity and Similarity of Bird Communities of Three Forest Fragments in an Urban Environment in Peninsular Malaysia

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ABSTRACT A study of changes on diversity and similarity of birds inhabiting three forest fragments around Kuala Lumpur, Malaysia was conducted in two sessions, 1991/1992 and 2000/2001. The study areas were Bukit Gasing Forest Reserve (BGF), Taman Seputih Forest (TSF), and a patch of green area next to First Residential College, Universiti Malaya campus (UMF). Birds were recorded either through direct observation or captured by mist-net. Five diversity indices (i.e. Shannon-Weiner, Simpson, Sorensen, Coefficient Community, and Equitability) were used to determine bird diversity and evenness. In total, 2457 birds comprising 73 species were recorded in the areas. Most of the birds were resident (78%), followed by migratory (11%), uncertain (7%), and introduced species (4%). The highest diversity value was in the BGF and the least was in the UMF. These two sites also shared more similar species than other areas; probably due to their closeness and similarity in forest structure. Results from this study clearly indicate that size and habitat complexity were two main factors that regulated distribution and composition of birds in the study areas.

ABSTRAK Satu kajian mengenai perubahan kepelbagaian dan kesamaan spesies burung yang mendiami tiga hutan kecil di sekitar Kuala Lumpur, Malaysia telah dijalankan pada 1991/1992 dan 2000/2001. Kawasan yang dikaji adalah Hutan Simpan Bukit Gasing (BGF), Hutan Taman Seputih (TSF), dan tompokan hutan bersebelahan Kolej Kediaman Pertama, Universiti Malaya (UMF). Kaedah yang digunakan untuk merekodkan burung di kawasan kajian adalah pemerhatian secara langsung dan pemerangkapan menggunakan jaring kabut. Untuk menentukan kepelbagaian dan kesamaan, lima indeks kepelbagaian iaitu Shannon-Weiner, Simpson, Sorensen, Koeffisien Komuniti, dan Kesamaan telah digunakan. Secara keseluruhannya, 2457 individu burung yang terdiri dari 73 spesies telah direkodkan. Kebanyakannya merupakan burung-burung residen (78%), migran (11%), spesies yang tidak dapat dikategorikan sebagai migran atau residen (7%), ataupun spesies yang diperkenalkan (4%). Nilai indeks kepelbagaian burung di BGF adalah yang paling tinggi manakala UMF menunjukkan nilai kepelbagaian yang paling rendah. Kedua-dua kawasan ini mempunyai kesamaan spesies yang lebih tinggi berbanding kawasan lain; mungkin disebabkan struktur hutannya yang hampir sama ataupun lokasinya yang berdekatan. Keputusan kajian ini jelas menunjukkan saiz dan kekompleksan habitat merupakan dua faktor utama yang mengawalatur taburan dan komposisi burung di kawasan kajian.

(bird diversity, forest islands, island size, urban area, urbanisation)

INTRODUCTION

Generally, diversity has been referred as the number of species that exists in a specific area. Therefore, it can be measured by species count (richness) and sometimes together with an evenness index [1]. Relative species abundance in a community affects species diversity and therefore, should be considered while measuring diversity. Several key ecological processes such as competition, predation, and succession can change diversity by altering proportional diversity [2, 3]. There are many important factors affecting bird abundance, such as temporal changes in forest vegetation structure, food availability, events in migratory and winter periods, nest predation, and brood parasitism [4].

Factors that influence species diversity and abundance in natural or continuous forest are different from urban forest fragments as they are regulated by different mechanisms [5]. Urban areas represent the extreme example of human-modified environment, with only remnants of the original habitat [6], have higher temperature than countryside [7], and high human density. Forest fragmentation can affect bird abundance due to changes in landscape setting, and this is very true for some birds such as birds of prey [8]. Despite this drawback, any green areas within urban area could have some advantages to wildlife because of less intensive agricultural practices, absence of hunting pressure, and reduced human disturbance [9]. Forest fragments in urban area can play an important role in urban bird's survival because they provide habitat, shelter and other resources to various species [10, 11]. While some birds have utilised these areas for a shorter period only (for instance as a stop-over point for refuelling during their migration process), others have fully exploited these areas as their permanent habitat. Thus, any forest patches within urban areas will eventually enhance the diversity of wildlife in that area.

This paper elucidates changes in the avifauna community of three forest fragments by exploring their diversity, abundance, and density. The study was done in 1991/1992 and was repeated a decade later. All study sites were located within urban landscape and were different in size.

MATERIALS AND METHODS

Two major surveys were carried out in 1991/1992 and 2000/2001. Both investigations were conducted for a period of twelve months, starting from July to June in the following year. Three forest fragments around Kuala Lumpur were extensively studied. These were Bukit Gasing Forest Reserve (BGF, 45 ha in size), Taman Seputih Forest (TSF, 7 ha in size), and a patch of green area adjacent to First Residential College, Universiti Malaya campus (UMF, less than a hectare in size). All study areas are located at longitude 101°40'E and latitude 3°05'N, and are situated in valley area surrounded by low hills (40-160 m). Birds in these areas were either observed directly using binoculars (10 x 40 magnifications) or captured by mist netting. Existing tracks within the study areas were used as transects for observing birds. There were two observation sessions: morning session, from 0700 hour to 1000 hour, and afternoon session from 1600 hour to 1800 hour. No observation was made before 0700 hour or after 1800 hour due to low light intensity inside the forest.

Twenty mist nets were erected for twelve hours (0700 hour to 1900 hour) at various locations in each forest fragment. Bird netting was terminated in cases of heavy rain or strong wind. All nets had a dimension of 12 m long and 2.7 m wide, with a mesh size of 36. To avoid ground predator, nets were set up 0.5 m above the ground and were visited hourly. Captured birds were identified according to Smythies [12], King *et al.* [13], Strange & Jeyarajasingam [14] and Jeyarajasingam & Pearson [15].

The diversity of birds was measured using Shannon-Weiner index or H' and Simpson index or D'. Bird sighting was used as an analogue for captures. This approach had proved useful by Hadidian *et al.* [16] in studying birds of Washington D.C. Relative species abundance was determined using standardised index (equitability or E_H' or E_D') that is typically on a scale ranging from near 0, which indicates low evenness or high single-species dominance, to 1, which indicates equal abundance of all species or maximum evenness [17, 18].

RESULTS

In total, 2457 individuals comprising 73 species of birds were recorded in this study. The total number of bird species present in each forest fragment varied according to forest size. The highest species number was observed in BGF (53 or 86% in 1991/1992 and 65 or 90% in 2000/2001), followed by TSF (37 or 57% in 1991/1992 and 36 or 59% in 2000/2001), and UMF with the least species number (25 or 42% in 1991/1992 and 18 or 30% in 2000/2001). Most of the species were resident (57 species or 78%), eight were migrant (11%), three introduced (4%), and the remaining five species (7%) of uncertain status. Most of these species remained resident within the study areas for a specific period only, before they migrated to other areas occasionally. The majority of the resident species were found in BGF (47 in 1991/1992 and 52 in 2000/2001), some in TSF (36 in 1991/1992 and 35 in 2000/2001), and only a few in UMF (24 in 1991/1992 and 17 in 2000/2001). Two study sites, TSF and UMF, only harboured one migratory species during each study session (Brown Shrike, *Lanius cristatus* in TSF and Tiger Shrike, *Lanius tigrinus* in UMF). Ten species of migratory birds were recorded from BGF in the 2000/2001 sessions, a remarkable increase compared to the previous session (Table 1).

For species with uncertain classification status, two were found in TSF in both survey sessions (Black-naped Oriole, *Oriolus chinensis* and White-bellied Swiftlet, *Collocalia esculenta*), and three species were present in UMF (Ashy Drongo, *Dicrurus leucophaeus* and Asian Paradise-Flycactcher, *Tersiphone paradisi* in the 1991/1992 session only, and Black-naped Oriole, *Oriolus chinensis* in both surveys). All five species with uncertain classification status were present in BGF during the 2000/2001 survey but only three species were recorded in the earlier survey (Table 1).

Eight species were widely distributed in the study sites (Appendix 1). These species, considered abundant were Barn Swallow (*Hirundo rustica*), Black-naped Oriole (*Oriolus chinensis*), Common Myna (*Acridotheres tristis*), Eurasian Tree-Sparrow (*Passer montanus*), House Crow (*Corvus splendens*), Philipine Glossy Starling (*Aplonis panayensis*), White-breasted Waterhen (*Amaurornis phoenicurus*), and Yellow-vented Bulbul (*Pycnonotus goiavier*). Although these birds were present in large number, they were not necessarily present in all study sites. For instance, all of these species were found in BGF during both surveys except White-breasted Waterhen, which was not recorded in the latter survey. Some species such as Black-naped Oriole, Common Myna, Eurasian Tree-Sparrow, House Crow, and Yellow-vented Bulbul were present in all the study sites during both surveys. Other species were restricted to specific study site. Three species that were widely distributed in BGF and TSF were not observed in UMF in both surveys. These were Barn Swallow (recorded in BGF only), Philipine Glossy Starling and White-breasted Waterhen (both species present in BGF and TSF only).

Rare or uncommon species also showed similar distribution pattern as observed in abundant species. Of the eleven species classified as uncommon, four were recorded in BGF only (Buff-necked Woodpecker *Meiglyptes tukki*, Crimson Sunbird *Aethopyga siparaja*, Flyeater *Gerygone sulphurea*, and Orange-backed Woodpecker *Chrysocolaptes validus*), five were restricted to BGF and TSF (Blue-tailed Bee-eater *Merops philippinus*, Hwamei *Garrulax canorus*, Jambu Fruit-Dove *Ptilinopus jambu*, Oriental Reed-Warbler *Acrocephalus orientalis*, and White-rumped Munia *Lonchura striata*), one was limited to UMF only (Olive-backed Woodpecker *Dinopium rafflesii*), and one was present in all study sites (Horsfield's Babbler *Trichostoma sepiarium*).

In terms of diversity value, BGF showed higher index in both censuses, followed by TSF and UMF. The highest value for Shannon-Weiner index was recorded in 1991/1992 in BGF ($H' = 3.059$), followed by TSF ($H' = 2.679$) and UMF ($H' = 2.521$). Although similar pattern of bird diversity was recorded from same study sites a decade later, the values were slightly decreased. In the 2000/2001 survey, the diversity value for bird community in BGF was $H' = 3.000$, higher than the bird community in TSF ($H' = 2.675$) and UMF ($H' = 2.045$). Similar pattern of diversity values were shown by Simpson index for all study areas. In both censuses, the bird community in BGF showed higher value compared to TSF and UMF. For equitability index ($E_{H'}$), the bird community in BGF showed higher value than their counterparts in TSF and UMF forests for both years. However, E_D' value demonstrated reverse pattern to $E_{H'}$ value. The former index showed that UMF birds had the highest value, followed by TSF, and lastly BGF (Table 2).

Comparison between the study areas showed that more similar species were present in 2000/2001 compared to the earlier census

(Table 3). In the recent survey, the values of Sorensen index (K) clearly indicated that more than half of the bird species present in BGF and TSF were similar. The number of similar species shared by these areas increased two-folds for a period of ten years, as there were only between 25 to 27% of similar species ten years ago. The presence of similar species in BGF and UMF remained relatively unchanged between the first and second surveys.

Table 1. Status of birds and number of species recorded in three forest fragments around Kuala Lumpur

Status	1991/1992			2000/2001		
	BGF	TSF	UMF	BGF	TSF	UMF
Migrant	5	1	1	10	1	1
Resident	47	36	24	52	35	17
Uncertain	1	0	0	3	0	0
Total	**53**	**37**	**25**	**65**	**36**	**18**

Table 2. Value of diversity indices for birds recorded from three forest fragments around Kuala Lumpur

Index	1991/1992			2000/2001		
	BGF	TSF	UMF	BGF	TSF	UMF
Shannon-Weiner, H'	3.059	2.679	2.521	3.000	2.675	2.045
Simpson, D'	0.919	0.885	0.891	0.897	0.881	0.802
Equitability, E_H'	0.870	0.742	0.782	0.718	0.732	0.707
Equitability, E_D'	0.232	0.245	0.277	0.215	0.240	0.277

Table 3. Values of similarity indices for bird community inhabiting three forest fragments around Kuala Lumpur

Index	1991/1992			2000/2001		
	BGF X TSF	TSF X UMF	BGF X UMF	BGF X TSF	TSF X UMF	BGF X UMF
Coefficient community, C	15.80	37.50	11.10	36.48	42.10	12.16
Sorensen, K	27.30	25.50	20.00	53.46	59.26	21.68

DISCUSSION

Results from this study had shown that the community composition of birds inhabiting three forest fragments around Kuala Lumpur had changed dramatically over a period of ten years (1991-2001). Although the number of locally extinct species involved in this study is quite low (only two species, viz Chested Munia (*Lonchura mallaca*) and White headed Munia (*Lonchura maja*), species composition especially in BGF and TSF had changed tremendously. The disappearance of the two species was mainly due to habitat destruction as a result of forest clearing for more residential areas. Both species occupied an open area located at the periphery of the forest fragments for nesting and food resources. These open areas, populated by various grasses such as *Imperata cylindrica* and short trees such as *Acacia auriculiformis* provided suitable places for the locally extinct munias. Although the total number of species in BGF had increased significantly, the diversity indices values remained constant. This indicates that while some new species were successfully colonising BGF, the current inhabitants had suffered population decline. Some species that disappeared from UMF probably had migrated to BGF.

The results from this study agreed with the "Island Biogeography Theory" proposed by MacArthur & Wilson [19], which states that larger area is able to accommodate more species than smaller area. BGF was the largest forest fragment in this study and harboured the highest number of bird species or diversity value, followed by TSF and UMF. This result also concurs with other studies on birds inhabiting forest fragments such as urban woodlands [10] and urban parks [20].

The birds in the study sites represented about 11% of Malaysia's bird fauna. This high value might be due to the closeness of the study sites with the continuous forest, located about 30 km away. This lowland secondary forest, Ulu Gombak Forest Reserve has 249 species of birds [21]. As shown by previous study, bird richness and abundance are highly correlated with the increasing distance from mainland, vegetation type, and fragment size [10, 22].

This study clearly indicates that size and habitat complexity are two main factors that regulate distribution of birds in the study sites. Previous study on urban bird communities and their habitat affinities clearly demonstrates a complex relationship between species richness, abundance, and habitat structures [16]. Habitat structure in each study site is correlated with the vegetation complexity in a habitat which directly influences bird diversity [23, 24]. Poorly developed forest has simple habitat structure, therefore, provides fewer opportunities for concealment and a more variable environment, and will harbour lower abundance of invertebrates on plants. Lower food abundance is probably the most important factor that results in the lower bird densities in specific area [25].

Sorace [9] had shown that habitat feature and probably human disturbances greatly affected the abundance of open-land bird species in Rome urban area. The author pointed out that avian species richness might be reduced by urbanization but the abundance of pest species might be promoted in urban parks. This is because pest species such as House Crow and Jungle Myna are very adaptable to environmental changes. The decrease of bird species in any forest fragments is closely related to the reduction in habitat quality of the particular site. Any development or urbanisation process will transform the original habitat and lead to increase in predation rate and reduce availability of shelters. Local extinction and/or reduction in species abundance of birds are expected to continue if the process of land abandonment continues [22].

Abundance and diversity of bird species in urban areas are also greatly influenced by the presence/lack of natural predator and the availability of food supplies. Omnivorous birds such as feral pigeons and house sparrows are frequently seen in urban forest fragments due to their ability to adapt to man-made environment. House sparrow for example, is a general feeder, flexible in choice of nest site, has few successful enemies and is very tolerant to disturbance in urban areas [23].

The existence of forest fragments in urban areas with increased habitat diversity and more available resources (such as nesting sites) can definitely enrich urban fauna. To promote the presence of decreasing species and an enrichment of urban fauna in any forest fragments within urban areas, the degree of human disturbance need to be reduced and a better management practice should be promoted.

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Appendix 1 List of bird species found in three forest fragments around Kuala Lumpur, Malaysia [Resident species (R) = breed locally throughout the year; migrant (M) = migrate to other areas (not locally) for some period of time during specific years; introduce (I) = species introduced into this country; common (C) = easy to find; abundant (A) = widely distributed; rare or uncommon (U) = observed less than ten times during study period].

1.	Abbott's Babbler *Trichostoma abbotti*	C; R
2.	Arctic Warbler *Phylloscopus borealis*	C; M
3.	Ashy Drongo *Dicrurus leucophaeus*	C; R/M
4.	Ashy Minivet *Pericrocotus divaricatus*	C; M
5.	Asian Paradise-Flycactcher *Tersiphone paradisi*	C; R/M
6.	Banded Woodpecker *Picus miniaceus*	C; R
7.	Barn Swallow *Hirundo rustica*	A; M
8.	Black-naped Oriole *Oriolus chinensis*	A; R/M
9.	Blue-tailed Bee-eater *Merops philippinus*	U; R
10.	Blue-throated Bee-eater *Merops viridis*	C; R
11.	Brahminy Kite *Haliastur indus*	C; R
12.	Brown Shrike *Lanius cristatus*	C; M
13.	Brown-throated Sunbird *Anthreptes malacensis*	C; R
14.	Buff-necked Woodpecker *Meiglyptes tukki*	U; R
15.	Chested Munia *Lonchura malacca*	C; R
16.	Common Iora *Aegithina tiphia*	C; R
17.	Common Koel *Eudynomys scolopacea*	C; R/M
18.	Common Myna *Acridotheres tristis*	A; R
19.	Crested Serpent Eagle, *Spilornis cheela*	C; R
20.	Crimson Sunbird *Aethopyga siparaja*	U; R
21.	Crimson-winged Woodpecker *Picus puniceus*	C; R
22.	Dark Necked Tailorbird *Orthotomus atrogularis*	C; R
23.	Eurasian Tree-Sparrow *Passer montanus*	A; R
24.	Fluffy-backed Tit-Babbler *M. ptilosus*	C; R
25.	Flyeater *Gerygone sulphurea*	U; R
26.	Greater Coucal *Centropus sinensis*	C; R
27.	Greater Racket-tailed Drongo *Dicrurus paradiseus*	C; R
28.	Green-winged Pigeon *Chalcophaps indica*	C; R
29.	Grey-headed Flycatcher *Culicicapa ceylonensis*	C; R
30.	Horsfield's Babbler *Trichostoma sepiarium*	U; R
31.	House Crow *Corvus splendens*	A; I
32.	House Swift *Apus affinis*	C; R
33.	Hwamei *Garrulax canorus*	U; I
34.	Jambu Fruit-Dove *Ptilinopus jambu*	U; R
35.	Japanese Sparrowhawk *Accipiter gularis*	C; M
36.	Jungle Myna, *Acridotheres fuscus*	C; R
37.	Large-tailed Nightjar *Caprimulgus macrurus*	C; R
38.	Lesser Coucal *Centropus bengalensis*	C; R
39.	Little Green Pigeon *Treron olax*	C; R
40.	Little Spiderhunter *Arachnothera longirostra*	C; R
41.	Common Tailorbird *Orthotomus sutorius*	C; R
42.	Magpie Robin *Copsychus saularis*	C; R
43.	Olive-backed Sunbird *Nectarinia jugularis*	C; R
44.	Olive-backed Woodpecker *Dinopium rafflesii*	U; R
45.	Olive-winged Bulbul *Pycnonotus plumosus*	C; R
46.	Orange-backed Woodpecker *Chrysocolaptes validus*	U; R
47.	Orange-bellied Flowerpecker *Dicaeum trigonostigma*	C; R
48.	Oriental Reed-Warbler *Acrocephalus orientalis*	U; M
49.	Oriental White-eye *Zosterops palpebrosa*	C; R
50.	Pacific Swallow *Hirundo tahitica*	C; R
51.	Peaceful Dove *Geopelia striata*	C; R
52.	Philipine Glossy Starling *Aplonis panayensis*	A; R
53.	Pied Triller *Lalage nigra*	C; R
54.	Pink-necked Pigeon *Treron vernans*	C; R
55.	Red Junglefowl *Gallus gallus*	C; R
56.	Red-eyed Bulbul *Pycnonotus brunnues*	C; R
57.	Richard's Pipit *Anthus novaescenlandiae*	C; R

58.	Rock Pigeon *Columba livia*	C; I
59.	Scaly-breasted or Spotted Munia *Lonchura punctulata*	C; R
60.	Scarlet-backed Flowerpecker *Dicaeum cruentatum*	C; R
61.	Spotted Dove *Streptopelia chinensis*	C; R
62.	Straw-headed Bulbul *Pycnonotus zeylanicus*	C; R
63.	Thick-billed Pigeon, *Treron curvirostra*	C; R
64.	Tiger Shrike *Lanius tigrinus*	C; M
65.	White-bellied Swiftlet *Collocalia esculenta*	C; R
66.	White-breasted Waterhen *Amaurornis phoenicurus*	A; R/M
67.	White-headed Munia *Lonchura maja*	C; R
68.	White-rumped or Sharp-tailed Munia *Lonchura striata*	U; R
69.	White-rumped Shama *Copsychus malabaricus*	C; R
70.	White-throated Kingfisher *Halcyon smyrnensis*	C; R
71.	Yellow Bellied Prinia *Prinia flaviventris*	C; R
72.	Yellow Wagtail *Motacilla flava*	C; M
73.	Yellow-vented Bulbul *Pycnonotus goiavier*	A; R