Spatial Patterns of Bird Diversity and Abundance in an Urban Tropical Landscape: The University of the Philippines (UP) Diliman Campus

Benjamin Vallejo Jr.[a*], Alexander Aloya[b], Perry Ong[c], Annette Tamino[d], Jonathan Villasper[e]

[a]Institute of Environmental Science and Meteorology, College of Science
University of the Philippines, Diliman, Quezon City
[b]Natural Science Research Institute, College of Science
University of the Philippines, Diliman, Quezon City
[c] Institute of Biology, College of Science, University of the Philippines
Diliman, Quezon City
[d]College of Science, University of the Philippines, Baguio City
[e]Department of Geography, College of Social Science and Philosophy
University of the Philippines, Diliman, Quezon City
E-mail: bmvallejo@up.edu.ph
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ABSTRACT

An analytical biogeographic analysis of urban bird diversity and abundance was conducted in the University of the Philippines Diliman campus from February to April 2005. Using the Jokimäki urban bird census technique on four different land use subplots we observed 36 species of birds and 4036 cumulative counts individuals of these species. The open field area had the highest number of species (23) while the residential area had the lowest species number (14). The residential area has the highest bird counts and the College of Science complex had the lowest number of counts. Linear regression analysis of landscape features on bird abundances reveals that the number of trees and buildings are most significant predictors of abundances. Spatial features and the trophic characteristics of the bird species are not significant factors to account for abundance. Trees and buildings affect the distribution and abundance of urban exploiting species *Passer montanus* and *Pycnonotus goiavier* with the former favoring built spaces and the latter favoring trees. Analysis of species area curves suggests that the bird community of the campus is not homogenized and that certain habitats allow uncommon species to persist. We recommend that in order to increase bird biodiversity existing green spaces must be preserved, fruit trees planted and in areas reserved for building development, pocket gardens and rooftop gardens be included in the landscape architectural design.

Key words: birds, biogeography, urban ecosystems, University of the Philippines, Metro Manila

[*]*Corresponding author*

INTRODUCTION

Urban environments are generally areas characterized by a growing human population, pollution, and conversion of natural habitat into 'built-up' areas. Like any major Asian metropolis where at least 10% of the national population resides, Metro Manila has about 12% of the entire population of the Philippines (Ohmachi 2002). Metro Manila's population growth rate is 3% per annum largely brought upon by migration from the provinces. Based on landscape statistics by the Philippines National Mapping and Resource Information (NAMRIA 2003), built-up areas in Metro Manila was estimated to be around 37.8% of the total land cover. Since urban areas are characterized as centers of human habitation, Philippine cities have not been considered as important areas for biodiversity conservation.

Many studies have shown that metropolitan areas still support significant levels of animal and plant biodiversity which includes the occurrence of rare species in wooded, green spaces (Gyllin 1999; Szacki 1999; Ong et al. 1999). Landscape developers and architects have long realized the importance of green spaces in mitigating microclimatological effects of overheating (Ohmachi 2002) and in helping maintain humidity levels (Szacki 1999) in built-up areas.

Green areas are generally locally fragmented and patchy in cities (Clemants & Moore 2003; Gilber 1992; Hobbs 1988) and this fragmentation may result in localized extinctions (Hengeveld 1993). In a recent study in a university campus in Brazil, habitat fragmentation resulted in a failure to sustain avian biodiversity (Manhães & Loures-Ribeiro 2005) Species richness decreased with increasing urbanization in Vancouver, Canada (Melles et al 2003). However, bird biodiversity loss in Metro Manila has been not well documented with the exception of possible extinctions recorded at the University of the Philippines Diliman campus in Quezon City. Four forest dwelling birds (mostly raptors) were recorded in the 1960s but have never been recorded since, making them locally extinct from the Diliman district (Ong et al. 1999).

Localized extinctions may be a result of species invasions by non-native species (Kowarik 1995; Blair 2004). Urban bird communities are usually characterized by the dominance of a few species (Beissinger & Osborne 1982; Marzluff 2001) and most of the species making up the communities are introduced. A low spatial variation of urban bird communities is expected and may probably result to more similar bird communities all over the world (Jokimäki et al. 1996). Urban birds are generally classified in three general categories: urban avoiders, suburban adaptable and urban exploiters (Blair 1996; McKinney 2002).

A growing number of amateur bird watchers and clubs (e.g. Wild Bird Society of the Philippines) in the last 10 years have recorded about 117 bird species in Metro Manila. Some of the accounted species are listed as endangered (Collar et al. 1999) and were mostly seen in wooded areas of universities, memorial parks, reclamation sites and in watersheds (e.g. La Mesa Watershed). The numerous observations by amateur and professional birdwatchers may support the idea of the conservation value of Metro Manila's green spaces. Nonetheless, there is not much scientific information on the distribution and habitat association (e.g. landscape ecological characteristics) of bird biodiversity.

In this research we investigate the possible effect of landscape features on the patterns of diversity and abundance of bird communities in the 493 hectare University of the Philippines (UP) Diliman campus. Several researchers have recommended local scale investigations in studying bird-habitat relationships aimed at the development of effective management decisions for the conservation of birds in urban habitats (Jokimäki & Jokimäki 2003; Clergeau et al. 2001).

METHODS

Study area

Our study area is the University of the Philippines Diliman campus in Quezon City (14^0 N, 121^0 E), Metro Manila (Fig. 1). The campus is located 15 kilometers from downtown Manila. It is a fully functional community and a local government unit. The campus has faculty and student residential areas, academic use areas, parks and commercial areas. The campus

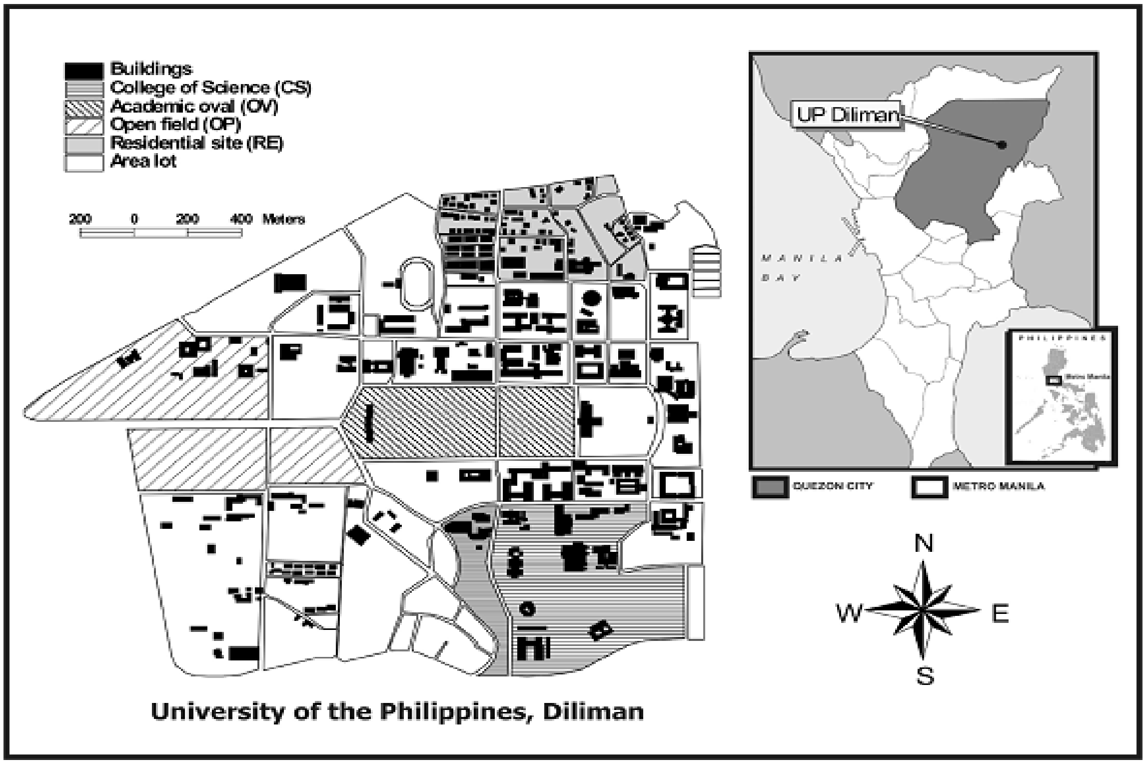

Figure 1. The University of the Philippines (UP) Diliman campus in northeast Quezon City, Metro Manila. Bird survey subplots are indicated.

daytime population is 40,000 composing of students, staff, employees and informal settlers. We use the campus as a model for Metro Manila's urbanization. Geophysical studies by Midorikawa and Bautista (2002) categorized the area to be part of the 'central plateau' or Guadalupe Tuff region of Metro Manila with an elevation of at least 10 meters above sea level. Rapid urban development began as early as 1947 when the campus was transferred from Ermita district in downtown Manila after the Second World War. The climate type is tropical monsoonal (Type I) with a pronounced dry season from November to April, and a pronounced wet season for the remainder of the year. The area is protected from the northeast monsoon, but open to the southwest monsoon and tropical cyclones.

Four survey sub-plots (20-25 hectares) were established within a 2 km × 2.5 km area. These plots were defined by existing university road networks and characterized by varying levels of land use and degree of infrastructure developments. Plots were spatially delineated as UP Academic Oval (OV), open space along University Avenue (OP), College of Science complex (CS), and the UP faculty and staff residential site (RE).

Bird census technique

We employed a bird survey designed for urban communities developed by Finnish biogeographers Jokimäki and Jokimäki (2003). We initially established four sub-plots (20-25 has.) within the UP Diliman campus which was normally surveyed during early mornings (0530-0800 H) and before sunset (1630-1800 H) at a pace of 10 ha/20 min walk. We surveyed each plot six times during the dry and hot season from February to April 2005. We conducted the census by walking a random zigzag route pattern in wooded and open spaces while following road pavements in the residential site. Careful bird counts were observed continuously through a fast-paced walk, taking note of bird movement across the route. This criterion is intended to avoid double or multiple counts of an individual. Birds which merely flew high overhead from the upper canopies or buildings were not included in the counts. Observations on bird species richness and abundance including microhabitat associations were noted on standard data sheets. All corresponding statistical analyses were based on cumulative counts of species recorded for the entire survey.

The Jokimäki method is designed to estimate the abundances of mainly resident perching birds (Passeriformes) that are usually associated with tree canopies and urban landscape features. The method cannot be used to estimate the abundance of birds with large foraging areas such as raptors and to detect extremely rare or cryptic species. While raptors have been observed by other researchers in campus, their sighting frequencies are rare and it is likely that these birds are migrants passing over the campus.

Ecological statistical analyses

We used the non-parametric statistic Spearman's coefficient (R_s) to determine the degree of correlation between species occurrence and abundance in all plots. To analyze bird community diversity, we used Shannon-Wiener's (H') and Simpson's (D) Diversity Indices. Shannon-Wiener index was generally used in ecological studies concerned with the number and abundance of rare species while Simpson's index for more abundant or common species (Peet, 1974). Hill's modified ratio (E_5) was used to compute for bird community evenness, where a value approaching 0 indicates single species dominance. Thus,

$$E_5 = N_2 - 1/ N_1 - 1 \qquad (1)$$

where: $N_1 = e^{H'}$ (exponential function of Shannon-Wiener index)
$N_2 = 1 / D$ (reciprocal of Simpson's index)

To measure the general trend in spatial species diversity among sub-plots, we obtained a species-area curve from nested plots. The derived curve describes the linear association of species richness with increasing sample size (Rosenzweig 1995). If a non-linear association emerges, then a case of homogeneity of bird fauna might exist between plots (Rosenzweig 1995).

In order to estimate effects of landscape features on bird abundances, we log-transformed abundance data before using stepwise linear regression analysis with Statistical Package for the Social Sciences (SPSS Version 13.0). Log-transformations were done to stabilize variances and fulfill parametric statistical assumptions. Ecologists have long accepted that biotic communities generally follow a lognormal distribution as species abundance values are affected by a range of complex processes and interactions in a community (Waiten 1999). Species abundance was also subjected to simple linear regression analysis with UP-Diliman landscape variables (Ballad et al. 2002, unpublished data). Data on species richness and occurrence were used to compute qualitative community similarities among sub-plots (Sörensen index):

$$C_N = 2_{jN}/(aN + bN) \qquad (2)$$

where aN is the total number of species recorded in Site A, bN, the total number of species recorded at Site B, while jN is the number of joint species occurrences for all sites.

RESULTS

Species richness and abundance

A total of 36 species were accounted in four sub-plots in UP Diliman (this includes 3 species accounted through opportunistic observations, see Table 1). Twenty or more species occurred in 3 sites: College of Science, UP Oval, and the Open field site. Only 14 species were detected in the residential area. Philippine endemics comprise 14% of the total species list including the Lowland White-eye *Zosterops meyeni*, which only occurs in the Luzon Faunal Region (LFR). Other endemics were Pink-bellied Imperial Pigeon *Ducula poliocephala*, Philippine Hanging-parrot *Loriculus philippensis*, Philippine Coucal *Centropus viridis*, and Philippine Pygmy-woodpecker *Dendrocopus maculatus*. Migrants make up 19% while introduced species 8%. Three out of the 4 known introduced breeding bird species in the Philippines were present in the study sites.

	Philippines	Luzon	This survey (UP Diliman)				
			Total	CS	OV	OP	RE
Total	572	391	36	22	20	23	14
Residents	198	137	19	14	11	14	8
Philippine endemic	176	100	4	2	3	1	1
LFR[b] endemic	25	25	1	0	1	0	0
Migrants	162	154	7	3	3	4	2
Introduced	4	4	3	3	2	3	2

[a]Residency data is taken from bird listings of Kennedy et al. (2000)
[b]Luzon Faunal Region
CS, College of Science; OV, Academic oval; OP, Open field site; RE, Residential site

Table 1
Summary of species richness and residency status of birds detected from February to April 2005 in UP Diliman[a].

Bird density

A total of 4,056 cumulative counts of individual birds were recorded for 33 species (Appendix 1). Positive correlation exists between abundance of birds and the number of site occurrences (R_s = 0.902, n = 33, P < 0.01). The residential site (although with only 14 species) appeared to have the highest absolute bird density with of 1,685 individuals (Table 2). Dominant species were Eurasian Tree-sparrow *Passer montanus*, Yellow-vented Bulbul *Pycnonotus goiavier*, Brown Shrike *Lanius cristatus*, and Pied Fantail *Rhipidura javanica* comprising >5% of the total number of occurring birds in all areas. It can be noted that *P. montanus* (x = 520.8, SD = 374.4, n = 4) and *P. goiavier* (x = 179.5, SD = 56.9, n = 4) composes majority of avian populations in all study plots.

Bird community diversity and evenness

Shannon-Wiener's index which provides a quantitative description of the intensity of species richness was highest at the OP site (H' = 1.8704) followed by CS (1.8536), OV (1.7951), and very least at RE site (1.3196, Table 3). Simpson's index was marginally highest at RE (D = 0.4337) with the other 3 sites having a range value of 0.24 to 0.26. Hill's index of diversity evenness was highest at OV (E_5 = 0.6048), followed by CS (0.5472), OP (0.5172) and RE (0.4763).

Linear regression analysis

A low R^2 value of 0.175 suggests the effects of scale in the regression model. The significant F-statistic from the ANOVA table (Table 5) shows the effectiveness of the regression model in explaining abundance as affected by various landscape variables (i.e. no. of trees, % cover of buildings and green spaces, feeding guilds). Coefficient values generated by the linear model indicates the number of buildings (á=0.014) and trees (á=0.004) as significant landscape predictors of bird abundance (Table 6). Other spatial attributes such as building and green-space cover appeared to be non-significant. Food preferences of bird species as indicated by feeding-guild values were also not significant.

(1) CS	(2) OV	(3) OP	(4) RE
P. montanus 43.9%	*P. montanus* 36.9%	*P. montanus* 46.7%	*P. montanus* 63.7%
P. goiavier 20.6%	*P. goiavier* 30.7%	*P. goiavier* 14.6%	*P. goiavier* 12.1%
L. cristatus 9.4%	*L. cristatus* 7.9%	*L. cristatus* 9.0%	*R. javanica* 9.3%
R. javanica 6.1%	*R. javanica* 7.7%	*G. striata* 8.5%	*G. sulphurea* 5.6%
L. schach 4.3%	*G. sulphurea* 6.0%	*R. javanica* 5.1%	*L. cristatus* 3.2%
H. tahitica 3.8%	*C. livia* 1.9%	*G. sulphurea* 3.9%	*H. tahitica* 2.3%
G. gallus 2.5%	*H. chloris* 1.5%	*G. gallus* 2.6%	*G. gallus* 1.2%
G. sulphurea 2.5%	*Z. meyeni* 1.5%	*H. tahitica* 2.4%	
M. palustris 1.7%	*H. tahitica* 1.4%	*L. schach* 2.1%	n= 1,685 individuals
G. striata 1.3%	*L. schach* 1.2%	*C. livia* 1.6%	
		S. chinensis 1.0%	
n = 635 individuals	n= 810 individuals		
		n = 926 individuals	

CS, College of Science; OV, Academic oval; OP, Open field site; RE, Residential site

Table 2
Summary of dominant bird species expressed as percentage of the cumulative number of birds counted in surveys (n=6) of four sub-plots in UP Diliman

Plot	H'	Simpson's	Evenness	No. of Buildings	No. of Trees	Building Area (m²)	Road Area (m²)	Green Spaces (m²)
CS	1.8536	0.2535	0.5472	24	3818	36,647.90	5,430	254,853.44
OV	1.7951	0.2478	0.6048	3	3737	6,546.83	2,760	144,771.09
OP	1.8704	0.2604	0.5172	13	1225	11,787.35	32,400	269,731.86
RE	1.3196	0.4337	0.4763	93	1662	33,169.73	17,100	114,171.21

*Data courtesy of Geodetic Engineering Department, and Training Center for Applied Geodesy and Photogrammetry, College of Engineering, UP-Diliman 2002
H' = Shannon-Wiener index of diversity

Table 3. Indices of bird community diversity and evenness, also shown are landscape data* in the 4 study plots in UP Diliman

Community similarity

Average bird community similarity among all sites is 61.4% (SD = 5.97, n = 6) of which sites CS and OP have the highest pairwise comparison with a similarity value of 71.1% (Table 7). Pair plots CS-RE and OV-OP were found out to have more different species occurrences with only about 55% similarity. The degree of species heterogeneity among the study plots can also be evaluated in the species-area curve derived from nested plot data (Fig. 2). The 0.94r^2 indiates strong correlation of species richness with increased sampling area. It implies further that some species may have special preferences on certain areas over the others. This could be attributed to habitat type and landscape factors (Jokimäki & Jokimäki, 2003), food availability, or competition from other types of species.

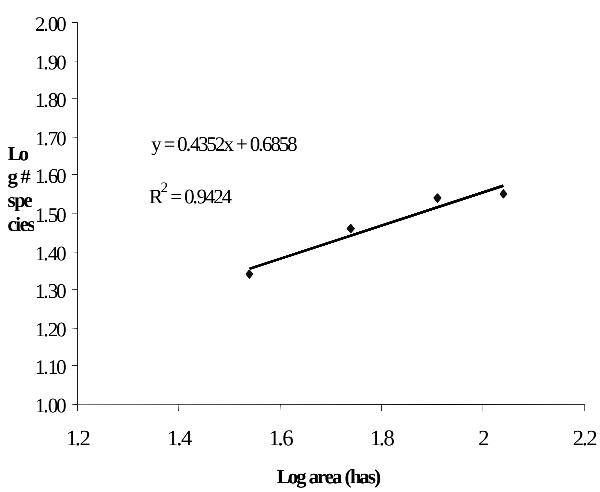

Figure 2. Species-area curve for bird nested data over six subplots in UP Diliman.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.934(a)	.871	.813	.39781(b)

a Predictors: feeding guilds, number of trees, number of buildings, spatial area of green spaces, spatial area of buildings

b Dependent Variable: LOG abundance

Table 4. Summary statistics of the regression model.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	23.602	10	2.360	14.914	.000(a)
	Residual	3.481	22	.158		
	Total	27.083	32			

a Predictors: feeding guilds, number of trees, number of buildings, spatial area of green spaces, spatial area of buildings
b Dependent variable: LOG abundance

Table 5
ANOVA table of linear regression analysis between log-transformed data on bird abundance with feeding guilds (biotic factor) and landscape variables (abiotic factors).

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	No. of buildings	.005	.002	.500	2.670	.014
	No. of trees	.000	.000	.666	3.228	.004
	Building area	-1.58E-005	.000	-.534	-1.326	.198
	Greenspace area	1.44E-006	.000	.391	1.295	.209
	Insectivores	.110	.230	.049	.476	.639
	Frugivores	-.178	.355	-.047	-.502	.621
	Omnivores	.381	.204	.198	1.873	.074
	Nectarivores	.291	.461	.055	.631	.534
	Seed eaters	.553	.333	.146	1.659	.111
	Carnivores	.106	.282	.038	.377	.710

a Dependent Variable: LOG abundance

Table 6. Correlation coefficients of various landscape variables and foraging habits with bird abundance over spatial scales.

Plots	% Similarity
CS-OV	61.9%
CS-OP	71.1%
CS-RE	55.6%
OV-OP	55.8%
OV-RE	58.8%
OP-RE	64.9%

CS, College of Science; OV, Academic oval; OP, Open field site; RE, Residential site

Table 7
Percent similarities (Sorensen index) of paired plots based on qualitative data (species occurrences).

DISCUSSION

This study detected about 9.2% of birds that can be found in Luzon with 5 species endemic to the Philippines. Nineteen species of the birds recorded by Ong et al. (1999) during October 1997 to January 1998 and June 1998 were detected in this survey. Difference in species accounts may be due to the time of survey (this one was conducted late February to April 2005), the method used, or some previously recorded species may have been locally extinct, escapees or were accidentally recorded. Nevertheless, results of this survey indicate persistence of a relatively diverse avifauna in UP Diliman campus since 1997. It is also a fact that no major habitat conversions were made in the study sites from year 1997 to the first half months of year 2005.

The presence of a number of Philippine endemic species *D. maculatus, D. poliocephala, Z. meyeni, L. philippensis,* and *C. viridis* makes the campus an important urban bird area. This study indicates that although endemics were present, their population represents only a mere 0.59% of the total bird community. This figure may have been affected by successful colonization by other introduced or resident species as a result of native faunal extinction (Blair 2004) or as a direct result of habitat conversion from its original state. It is unknown whether this small fragment of endemic birds found in the study sites were remnant population, re-introduced or 'regular foragers' from adjacent disturbed forest blocks. What is certain is the vulnerability of the endemic population even to slight habitat disturbance or modifications.

Our data on bird densities showed two species dominating bird population in all study plots, *P. montanus* making up 51.4% and *P. goiavier* 17.7% of the cumulative bird count. *P. montanus* is a communal seed-eater that was introduced in the Philippines in the 1930s (Ong et al. 1999) while *P. goiavier* is resident breeding an omnivore, present in all terrestrial habitat type except in mature and secondary forests. Another species which has also been found abundant in all four plots is the pied fantail *R. javanica* (7.5%). The ability of these species to dominate bird populations in the area categorizes them as 'urban exploiters' (Blair 1996; McKinney 2002). Thus, these species may have directly benefited from earliest land conversion and development in UP Diliman and in all other areas in Metro Manila.

The community diversity and evenness indices showed how various land-use schemes determine bird species richness. Species evenness was highest at the OV site with a value of 0.6048 indicating higher community diversity wherein large numbers of species are all similarly abundant (Table 3). This may be attributed to the continuous block of wooded areas in the park and minimal number of buildings (n = 3). The low Shannon-Wiener (H') and evenness value (E_5) in the RE site is the function of low species richness and diversity. RE had the most number of recorded individuals with 1,685 but composed only of 14 species. It should be noted that this plot is residential with the most number of infrastructures (number of single-family houses = 93). Accordingly, bird community structure is primarily composed of species that are commensal with humans such as *P. montanus* (64%). Our data indicates contrary result from the findings of Jokimäki & Jokimäki (2003) in urban centers in Finland wherein bird diversity was observed to be higher in single-family house areas. This could be the case since their data indicated minimal 'built-up' spaces in residential areas that are located in sub-urban localities in developed countries (i.e. Finland). However there are lesser areas of green spaces in highly urbanized cities like Metro Manila. This was the case in RE site wherein it has the lowest green space area of approximately 114,000 m^2 among other plots.

Our findings suggest the influence of landscape-gradient variables in determining local abundances structure of birds in a tropical urban environment. This is a result that supports Melles et al (2003). It appears in our analysis that abundance was determined by the number of spatial entities (i.e. number of buildings and trees) and not by spatial area (i.e. area in m^2 of built-up and green spaces) or food preference (i.e. feeding guilds). This finding contrasts with that of Lim and Sodhi (2004) who found that increasing urbanization adversely impacted on insectivorous and carnivorous feeding guilds. In our study, insectivorous birds seem to have adapted to the urbanizing landscape. We did not observe carnivores that were probably extirpated in the 1960s as suggested by Ong et al (1999). This finding supports the general idea that typical urban birds primarily respond to architectural features and secondarily to natural features of the environment (Savard & Falls 2001). Bird species following this scheme were the most abundant especially for the highly adaptable and communal species, *P. montanus*. The more numerous the number of buildings, the more places these species find suitable foraging and nesting grounds. This phenomenon was further observed in our data as the distribution patterns on bird abundance were highly maximal towards 'urban exploiter' species like *R. javanica*, *L. cristatus*, Zebra Dove *Geopelia striata*, and *P. goiavier*. Apparently, landscape homogeneity and increased proportion of built-up spaces (e.g. RE site) lowers bird community diversity and evenness.

Without much habitat modifications since the wildlife inventory in 1999, the UP Diliman campus still harbors a viable complex ecosystem for bird communities. Despite pressures by urban sprawl inherent in highly urbanized areas (Blair 2004), a considerable number of endemic species still persist. However, populations of these birds were very marginal compared with other highly urban-adaptable species. Our results indicate that increased number of infrastructure and homogenizing landscape (e.g. residential site) greatly contributes to lower biodiversity patterns and domination of commensal, urban exploiting species. However, various land-use types in the campus appear to contribute to the heterogeneity of bird communities. This was evident the fact that there was moderate similarity in terms of birds species composition among sites.

In order to preserve and promote diversity of bird species in the area, complex habitats should be sustained by preserving green spaces such as gardens and parks. Recent research on tropical urban bird communities in Brazil indicate that isolated forest patches within urban areas fail to sustain high bird biodiversity (Manhães & Loures-Ribeiro 2005). A possible solution to mitigate biodiversity loss is to ensure that these patches be preserved as to provide refuges and resource areas for birds (Melles et al 2003). Artificial habitats may also mitigate biodiversity loss. Thus we recommend that in areas reserved for building development, pocket gardens, rooftop gardens and parks must be integral to the landscape design. The planting of fruiting trees (not necessarily of economic value to humans) should also be encouraged. In Singapore, low density housing developments with suitable gardens planted to fruiting trees favored the persistence of frugivores (Lim & Sodhi) Endemics such as the lowland white-eye *Z. meyeni* were only seen once during this survey in a flock composed of 10-12 individuals in the upper canopies of fruiting mango trees in the OV site. A number of urban bird researchers in developed countries recommend increasing biodiversity by attracting minority species in the community but are capable of utilizing resources available in urban landscapes (Blair 1996; Jokimäki & Suhonen 1998). A good example would be the endemic pygmy woodpecker *D. maculatus*, an insectivore which is locally uncommon in UP Diliman. The bird's population has the potential to increase the fact that it appears to mimic more common birds (e.g. Eurasian tree sparrows) and it does not depend on fruiting or flowering trees for food. It however is a cavity nesting species that probably existed in greater abundances before rapid urbanization. The planting of suitable nesting trees may help in its population recovery.

We suggest that further research be conducted on the inability of rainforest birds to persist in an urbanizing landscape. This is a finding noted by Lim and Sodhi (2004) that is likely applicable to the Philippine situation. As most of the escapee pet birds we have observed in campus were of rainforest origin, the question of whether they can persist in an urban landscape has important conservation implications. Anecdotal evidence from the WBCP suggests that at least one parrot species has established itself in Metro Manila.

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Species	CS	OV	OP	RE
Acridotheres cristatellus	0	0	4	0
Alcedo atthis	0	1	0	0
Anthus novaeseelandiae	2	0	1	0
Cacomantis variolosus	4	0	0	0
Centropus viridis	2	2	0	0
Chalcochaps indica	0	0	1	0
Columba livia	3	15	15	5
Dendrocopus maculatus	0	5	1	5
Dicaeum sp.	0	1	0	0
Ducula poliocephala	0	2	0	0
Galirallus sp.	0	0	0	1
Gallus gallus	16	0	24	20
Geopelia striata	8	4	79	13
Gerygone sulphurea	16	49	36	95
Halcyon chloris	5	12	6	0
Hirundo tahitica	24	11	22	38
Ixobrychus cinnamomeus	0	0	2	0
Lanius cristatus	60	64	83	53
Lanius schach	27	10	19	0
Loriculus philippensis	2	0	0	0
Megalurus palustris	11	3	5	0
Megalurus timoriensis	3	2	0	0
Motacilla cinerea	1	0	2	0
Muscicapa griseistica	0	3	0	0
Nectarinia jugularis	0	4	0	6
Passer montanus	279	299	432	1073
Phylloscopus borealis	0	0	1	10
Pycnonotus goiavier	131	249	135	203
Rhipidura javanica	39	62	47	157
Sterna/Chlidonia sp.	0	0	1	0
Streptopelia chinensis	2	0	9	6
Turdus sp.	0	0	1	0
Zosterops meyeni	0	12	0	0

CS, College of Science; OV, Academic oval; OP, Open field site; RE, Residential site

Appendix 1
Abundance matrix of regularly occurring birds in 4 survey plots in UP Diliman (CS, College of Science complex; OV, Academic oval-park; OP, Open field site; RE, University residential area)