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Responses of the bird community in the University of the Philippines Diliman after campus redevelopment and the decline of two common urban bird species

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The response of the bird community in the University of the Philippines Diliman Campus was evaluated before and after the university embarked on major infrastructure and landscape development in 2006-2008. Surveys using the Jokimäki walk were made monthly from 2004-2006 prior to development and from 2007-2010 after development in three 22-25 ha plots, i.e., 1) College of Science (CS), 2) Academic Oval (OV) and 3) Open Fields (OP), representing biophysical development gradient. Diversity indices before and after redevelopment were compared. Principal components analysis (PCA) and Ordinary least squares (OLS) regression were done to determine how the dominant species responded to change over time. The Eurasian Tree Sparrow *Passer montanus* and the Yellow vented bulbul *Pycnonotus goiaiver* experienced declines in all plots but most significantly in the CS plot which experienced the most infrastructure development. A MANOVA was used to determine if the declines in *Passer* and *Pycnonotus* populations had an effect on other species in the CS plot. MANOVA results suggest that the declines are significant with the increase in populations of the flycatcher *Gerygone* and the ground dove *Geopelia s*uggesting ecological replacement of the once numerous species.

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INTRODUCTION

The University of the Philippines Diliman (UP Diliman) (14° 38' N, 121° 2' E) in Quezon City, National Capital Region, Philippines embarked on a campus wide development as a result of its centennial celebration in 2008. Redevelopment started in 2005 at the publicly funded research university finishing construction of the National Science Complex, and the National Engineering complex in the five years since the centennial celebrations.

This infrastructure activities were needed to improve the research and teaching capabilities of the university. The science complex is on a 21.9 hectare site to the southeast of the campus core with each of the science institutes having its own building in this property.

A habitat characterization and bird ecological study was conducted prior to campus redevelopment in 2005 (Ong et al. 1999, Vallejo et al. 2008, Vallejo et al. 2009). Before redevelopment, the sites where the National science and engineering complexes are now consisted of mixed grassland with trees and short watercourses. This mosaic of habitats is called in the Tagalog Filipino language as "parang" (Brown 1919). Parang is considered to be the most common habitat in Quezon City and the rest of Metropolitan Manila before it became heavily urbanized in

KEYWORDS
bird communities, University of the Philippines, Metro Manila, landscape changes, urban ecology, population decline

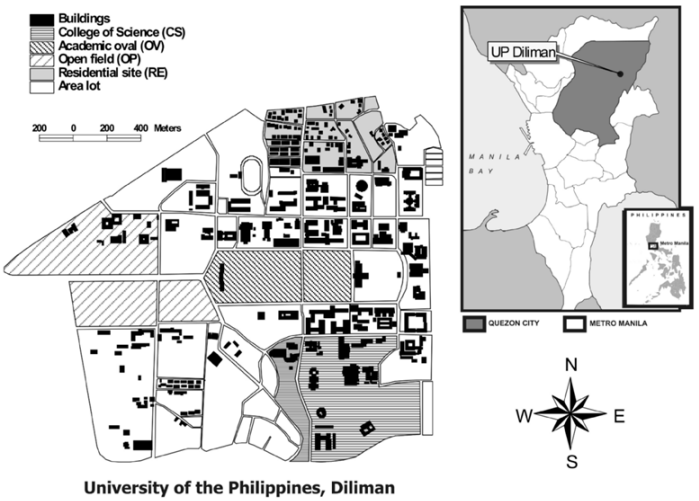

Figure 1. The UP Diliman campus with survey plots for the urban bird ecology surveys prior to campus development. In measuring the impacts of development, the OP, CS and OV plots were surveyed post campus development.

the last 70 years. The "parang" habitat is also sites of subsistence agriculture which persisted in the UP Diliman campus until the start of redevelopment in 2005.

Based on birdwatcher observations, the UP Diliman campus hosts at least 110 bird species. However systematic ecological studies by Vallejo and co-researchers estimate 56 species, 42 of which were observed in the National Science Complex site (Vallejo et al. 2008, Vallejo et al. 2009). Many of the birds recorded are low in abundance and uncommon to rare with 47.1% considered rare (Vallejo and Aloy 2008). All these observations were made before redevelopment took place. Bird surveys were suspended from 2005 to 2008 as a result of construction which limited access to the sites. When the construction was largely finished bird surveys were resumed. Thus, it is possible to compare bird species abundances, richness and diversity prior and post campus redevelopment.

The aim of this study is to document effects of development on bird abundances and community indices, especially on the common *Passer montanus* and *Pycnonotus goiaiver*. This paper is fourth in a series of studies made by the authors on bird communities of Metropolitan Manila.

MATERIALS AND METHODS

We used the Jokimäki walk (Jokimäki and Jokimäki 2003) in rapid assessment of bird abundance and diversity in the College of Science National Science Complex (CS), Academic Oval (OV) and the Open Fields (OP) (Figure 1). Our observations span the period of 5 years from 2004-2006 and 2007-2010 with 60 Jokimäki walks, 25 for 2004-2006 and 35 for 2007-2010 (total or x walks over x seasons and years) made in each plot. The CS plot has a faunal similarity index of 71.1% with the OP plot prior to campus redevelopment. The reason is that the OP and CS plots have essentially similar "parang" habitats and thus are ecologically comparable. Prior to campus redevelopment, these plots were minimally managed as open spaces. The OV plot is not slated for infrastructure development but for landscape development which includes rechanneling the creek that feeds the UP Lagoon, pathway improvement and lighting. The OV plot is zoned as a common park and events space for the university community. The OP plot was used as a control in this study. This plot along University Avenue at the entrance of the university is not slated for redevelopment but is zoned as an open parkland space. However at present it is maintained as a managed parkland environment with regular trimming and manicuring of grasses. Golfers have begun to use the site as an informal driving range.

The CS, OV and OP plots represent a gradient of infrastructure development in the campus. The CS plot is developed for academic and research uses, the OV plot for sport, recreation and cultural events, and the OP plot solely as an open green space.

The method we used and its rationale are described in an earlier study (Vallejo et al. 2008). The Jokimäki walk is essentially a random plot-less sampling technique on a defined urban parkland lot not greater than 25 ha in area. The plots were normally surveyed during early mornings (0530-0800 H) and before sunset (1630-1800 H) at a pace of 10 ha/20 minute walk. We conducted the census by walking a random zigzag route pattern

Table 1. Diversity indices before and after campus redevelopment.

Diversity index	Means		Significance
	Before	After	
College of Science			
Taxa	17	19	
Dominance	0.183	0.187	
Shannon Diversity	2.181	2.057	
Evenness	0.572	0.567	
Open Fields			
Taxa	12	15	p=0.014
Dominance	0.241	0.212	
Shannon Diversity	1.841	2.041	p=0.02
Evenness	0.540	0.526	
Academic Oval			
Taxa	10	16	p<0.00001
Dominance	0.284	0.234	p=0.013
Shannon Diversity	1.613	1.939	p=0.00014
Evenness	0.525	0.448	p=0.02

in wooded and open spaces. Careful bird counts were observed continuously through a fast-paced walk, taking note of bird movement across the route.

Survey months served as a temporal sampling unit since it was impossible to designate replicate plots or sub-plots given the nature of land use in the campus. While it may have been more ideal to have regular sampling dates per month, the Jokimäki walk surveys require fair weather for consistency of observations and this was not possible during the wet season. Taking into consideration maintaining sampling frequency in good weather, some months may have more than two surveys each. Also surveys were not possible during the time when the plots undergoing development were closed to public access.

Temporal sampling units require that there should be minimal seasonal variation in community indices within the before and after development sampling periods. Shannon Diversity indices in all sites have insignificant seasonal variation.

We used the non-parametric statistic Spearman's coefficient (R_s) to determine the degree of correlation between species occurrence and abundance in the plots which could help us infer faunal turnover. To describe bird community diversity, we used number of taxa (T), Shannon-Wiener's (H'), Evenness (E) and Simpson's (D) Diversity Indices for each site using the Paleontological Statistics Software Package (PAST) of Hammer et al. (2001). To compare H', E and D means before and after development, we used a t test assuming unequal variances for each site.

We hypothesized that land use changes due to building development caused a decline in bird abundances and changes to community characteristics. We used a principal components analysis (PCA) of bird abundance over the date of observation to determine if this hypothesis is plausible. To test these hypotheses of significant decline in the period of observation, an OLS regression was made over species abundances over time.

To test if there are positive or negative relationships between declining and increasing species in plots where these are observed, a multivariate analysis of variance (MANOVA) was used where the observed species that have a significant decline are the independent variables and the species that show increase over time are the dependent variables. This is to get possible inferences on the ecological roles of these species in disturbed environments. If there is a relationship between the declining species and the increasing species, then it can be assumed that the declining species share similar ecological niches with the increasing species.

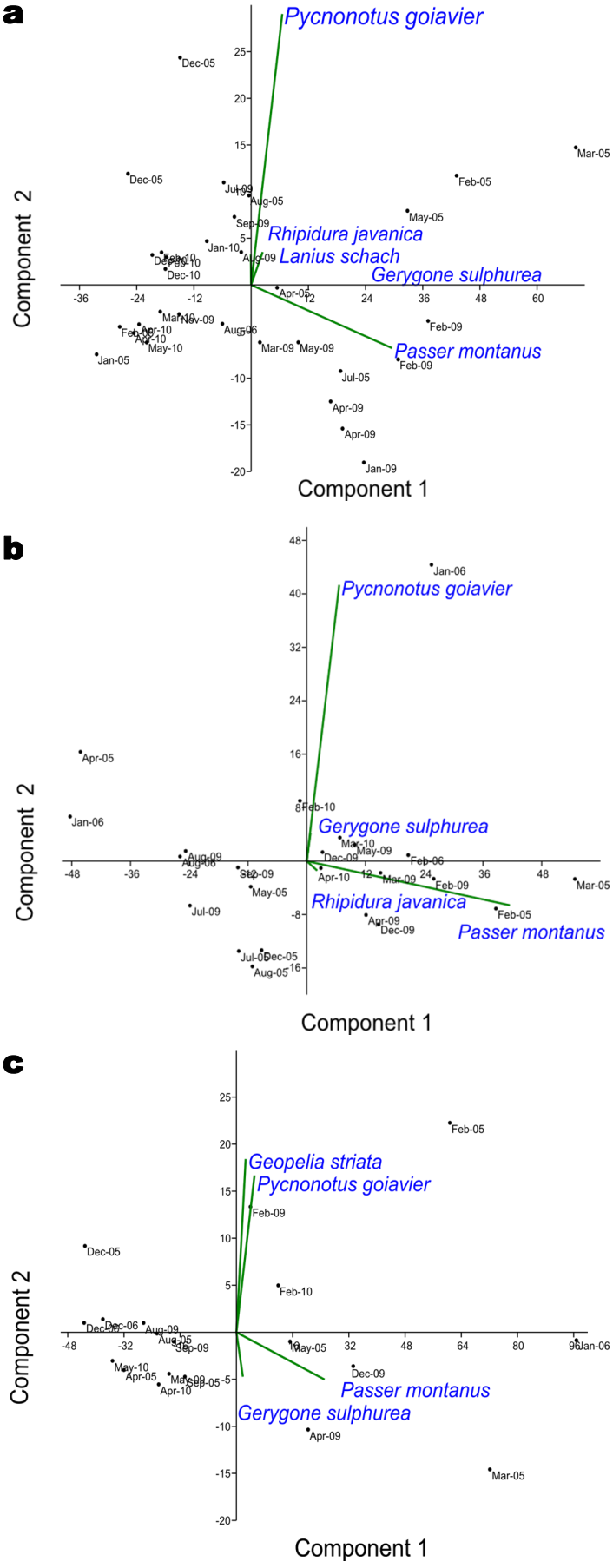

Figure 2. PCA biplots of bird abundances over date as a sampling unit. a, College of Science (CS); **b**, Academic Oval (OV); and **c**, Open Fields (OP).

Table 2. Principal component loadings and percent variance accounted for bird abundance counts in all survey sites.

Plot	Principal component number					
	1		2		3	
	Eigenvalue	% variance	Eigenvalue	% variance	Eigenvalue	% variance
CS	603.468	85.856	88.1922	12.547	6.7538	0.96087
OP	1684.05	92.775	74.3361	4.0952	38.0994	2.0989
OV	638.711	76.858	148.864	17.913	38.7071	4.6578

RESULTS

Spearman's coefficient (R_s) statistics between species occurrence and abundance were significant ($p<0.01$) in the CS and OP plots while it was not significant in the OV plot ($p=0.5$). This supports the hypothesis of population decline in these plots with less faunal turnover due to immigration. This interpretation is supported by the t test before and after comparison statistics of community diversity indices (T, H', D' and E) for the OV plot which are all significant. Diversity change in the OV is likely attributed to immigration as more species migrated into the plot (Table 1). Immigration resulted in a decrease in D' and E suggesting a community which is not in equilibrium.

In contrast, these indices were all not significant for the CS plot. This suggests little immigration, and D and E' indices remain the same despite an observed decline. For the OP plot, only T ($p=0.014$) and H' ($p= 0.02$) were significant. These suggest a degree of faunal turnover in the OP plot which may also suggest that in this grassland environment immigration is an important determinant in the bird community of the plot (Table 1). Similar evenness and dominance estimates suggest a community that is more likely in equilibrium than that of the OV.

In all plots, the following species were common: the Eurasian tree sparrow *Passer montanus,* the yellow vented bulbul *Pycnonotus goiaiver*, the golden belly flycatcher *Gerygone sulphurea,* the ground dove *Geopelia striata* (especially in the OP plot) and the Java fantail *Rhipidura javanica.* The abundances of these species were used in PCA to determine if their numbers were affected by landscape changes due to campus development.

PCA results suggest that for all sites, the abundances of *Passer montanus* and *Pycnonotus goiaivier* and *Rhipidura javanica* were affected by development. In all plots, the ordination vectors of *Passer* and *Pycnonotus* are almost orthogonal thus suggesting that campus development affected *Passer* and *Pycnonotus* in different trajectories (Figure 2). The first principal component which accounted for a large percentage of variance in the three plots (Table 2) reflects on the date of observation as a sampling unit and how the most abundant taxa responded over time. Since most variation is accounted for by the first principal component, ecological interpretation for all plots will be limited to how the dominant species are correlated with this component. *Passer montanus* is strongly correlated with this principal component thus showing that over time, the species changed in abundance. *Pycnonotus* is positively but less correlated which shows that there is also a change. *Gerygone* and *Rhipidura* show less correlation suggesting that they were not significantly affected by landscape change (Figure 3).

The OLS regressions show that *Passer* and *Pycnonotus* population trajectories in the CS plot have significant negative slopes thus confirming population decline. This is reflected in

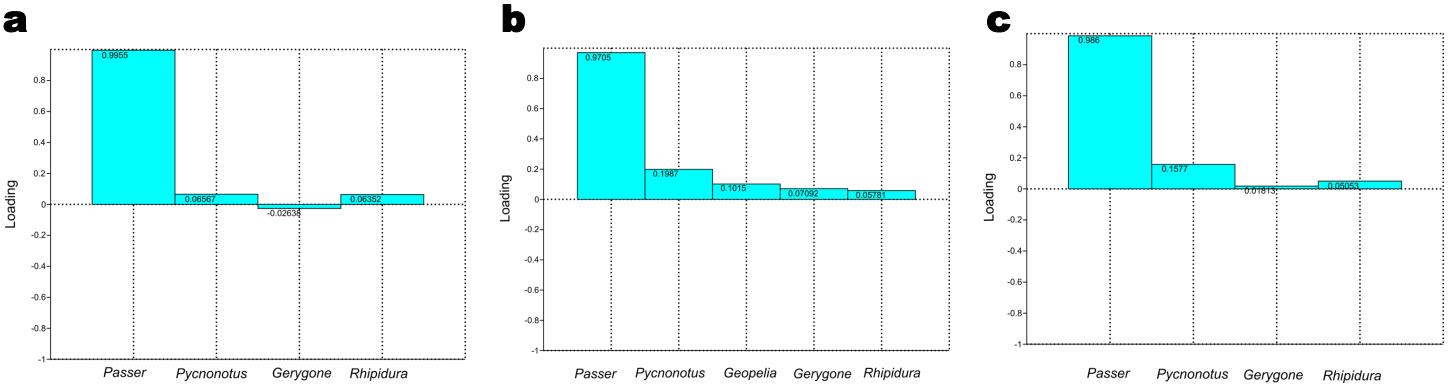

Figure 3. Loadings of the most abundant species on the first principal component. a, College of Science (CS); **b**, Open Fields (OP); and **c**, Academic Oval (OV).

the plot of total bird and taxon counts before and after development (Figure 4). In the CS plot, the more abundant *Passer* appears to have experienced a faster decline than *Pycnonotus* which appears to be more resilient. *Passer* (p=0.022) and *Pycnonotus* (p=0.033) showed significant declines (Figure 7). The other species, *Gerygone* and *Geopelia,* showed population increases but these were not significant. *Rhipidura* showed decline but this was not significant. In inferring possible competitive exclusion between the declining *Passer* and *Pycnonotus* and the increasing *Gerygone* and *Geopelia*, we note that MANOVA results suggest that *Passer* decline is significantly correlated with the increase in *Geopelia* (p=0.003) populations, but not with *Gerygone*. *Pycnonotus* decline is marginally significant with the increase in *Gerygone* (p=0.07), but significant with the increase in *Geopelia* populations (p=0.04).

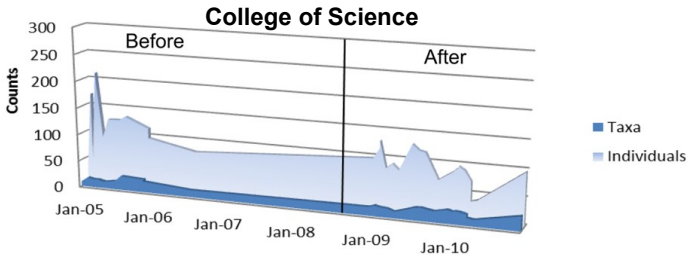

Figure 4. Trends in total bird abundances and taxon counts before and after development in the College of Science plot.

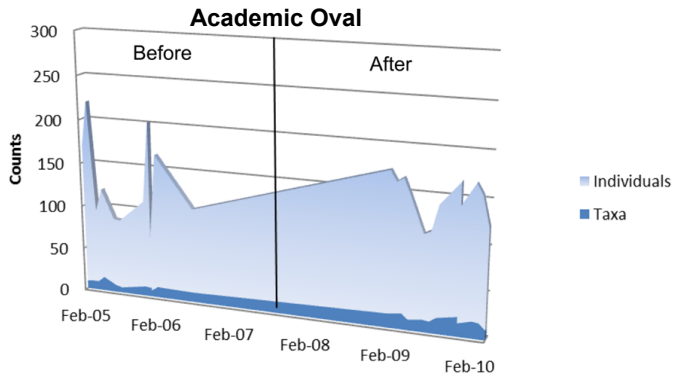

Figure 5. Trends in total bird abundances and taxon counts before and after development in the Academic Oval plot.

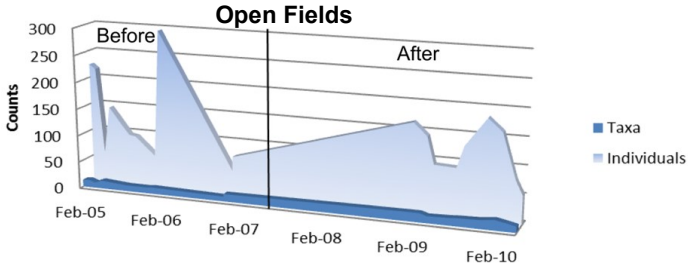

Figure 6. Trends in total bird abundances and taxon counts before and after development in the Open Fields plot.

In the OV plot (Figures 5 and 8), *Passer, Pycnonotus,* and *Geopelia* and *Rhipidura* showed population declines but were not statistically significant. *Gerygone* hardly showed population changes. None of the dominant species in the OP plot exhibited significant decline after campus redevelopment (Figures 6 and 9).

The other species previously reported in UP Diliman are uncommon to rare and, due to their rarity, a comparison between their abundances before and after campus development does not reveal any informative inferences. Their persistence in the changing landscape is likely due to immigration from nearby green spaces, most likely the secondary forests of the southern Sierra Madre ranges or the watershed forest of the La Mesa Dam in Novaliches, 8 km from the UP Diliman campus.

DISCUSSION

The decline of the two most abundant species, *Passer montanus* and *Pycnnotus goiavier,* is of interest in assessing environmental change in UP Diliman. Declines are most significant in the CS plot which has experienced the most redevelopment as the National Science Complex. *Passer montanus* is an urban commensal in tropical Asia and can survive in highly built-up areas (Sodhi and Sharp 2006), while *Pycnonotus* presence is more correlated with green cover in the landscape (Vallejo and Aloy 2008, Vallejo et al. 2009). Nonetheless, both species are urban tolerant but require green cover for breeding success. Urban parkland environments appear to suit them best by providing nesting trees.

While *P. montanus* is an urban commensal in tropical Asia, in temperate Eurasia, America and Australia it is a species characteristic of open parkland or farmland, while its congener *P. domesticus* is associated with urban areas. Conversion of these landscapes to urban uses have caused the rapid decline of both species of *Passer* and, for *P. domesticus*, a major factor for decline is lower chick survival as parent birds fail to find enough invertebrate prey to feed their chicks (Vincent 2005). A similar observation was noted in studies on *Passer* demographics in Warsaw, Poland where egg and chick mortality were the major factors for population decline related to the lack of insect prey (Pinowski et al. 1994). In Japan, populations of *P. montanus* have declined by 90% since the early 1960s as a result of conversion of agricultural landscapes to urban areas (Mikami 2009). Based on birdwatcher observations, *Passer montanus* has been on the decline in Britain for over a hundred years and this can be attributed to landscape changes (Summers-Smith 1989).

There is no information on *P. montanus* demographics in the Philippines. However it is reasonable to hypothesize that if there are perceived declines, an association is likely to be correlated with increasing high density urbanization in Metropolitan Manila and the poor survival of nestlings to be due to the lack of insect prey. Suburban and low density urban areas may harbour enough green areas for insects. As urbanization results in high density

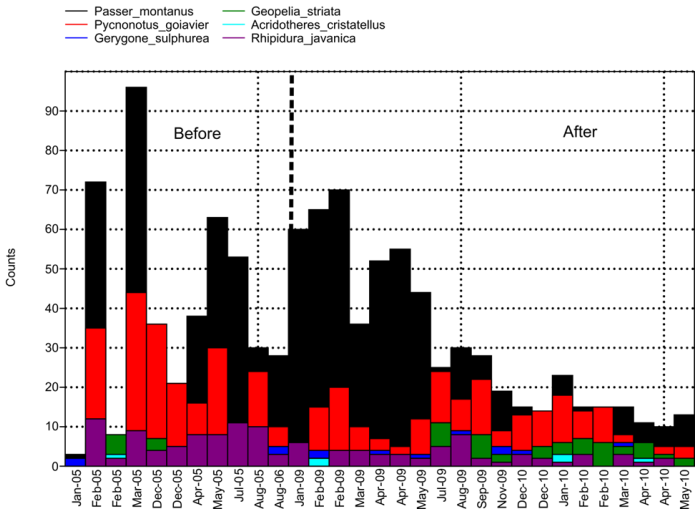

Figure 7. Trends in the abundances of the six most common resident species in the CS plot.

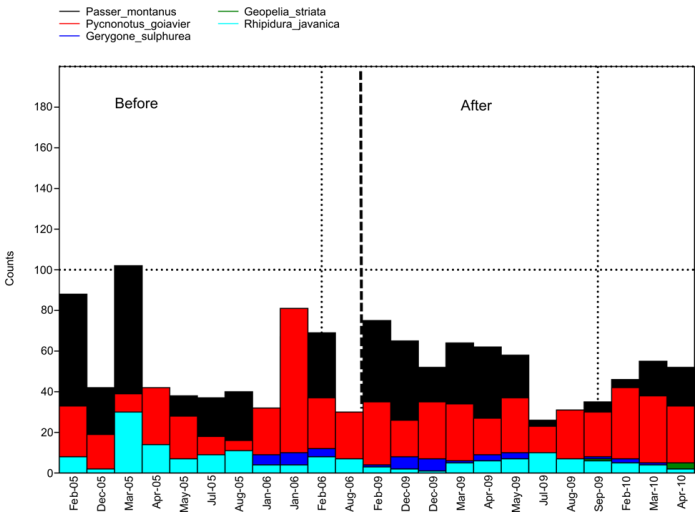

Figure 8. Trends in the abundances of the five most common resident species in the OV plot.

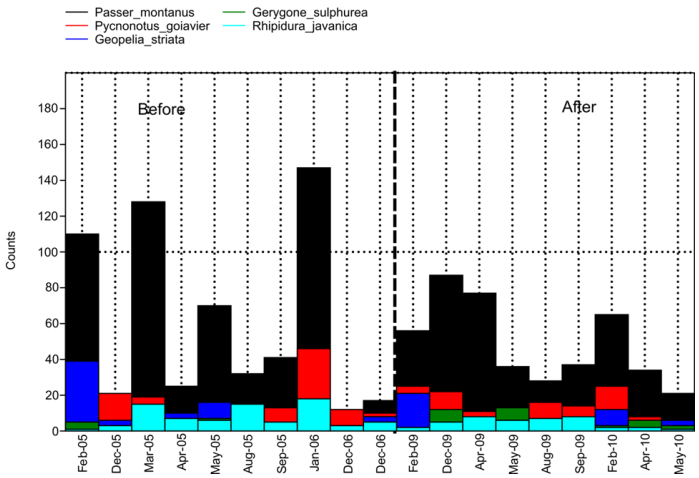

Figure 9. Trends in the abundances of the five most common resident species in the OP plot.

habitations, consequences of insect vector-borne diseases like dengue become a public health concern. This compels local government authorities and homeowners to use more pesticides. The widespread use of pesticides in urban and agricultural environments is a major correlate for the decline of *Passer* (Mikami 2009, Pinowski et al. 1994, Vincent 2005) in temperate Eurasia, not by directly killing the adults which are resilient but impacting on the birds' invertebrate prey thus affecting reproductive success. The birds are forced to feed their chicks with low protein plant material thereby contributing to high nestling mortality (Vincent 2005).

The effects on *Pycnonotus* are likely similar as this bird is a generalist insectivore. This species appears to require more green cover and the removal of nesting trees may impact their populations. Another insectivorous species, *Rhipidura javanica*, shows a decline in abundances although not statistically significant.

The slight but insignificant increase in *Gerygone* and *Geopelia* in the CS plot may be explained by landscape changes giving an opportunity for these species to fill in the ecological spaces vacated by the decreasing *Passer* and *Pycnonotus* populations. This is consistent with the competitive exclusion theory (Hardin 1960). In an ecosystem with less insect prey, *Passer* may feed on grass seeds (Vincent 2005), which is the main diet of *Geopelia* (Sodhi and Sharp 2006). With the one competing species reduced, it can be expected that *Geopelia* will exploit these resources and increase in number most likely by immigration. *Gerygone* is an insectivore and its increase in the CS plot remains unexplained. Perhaps it overlaps in habitat or prey requirements with the omnivorous *Pycnonotus*. In contrast, minor landscape changes can be attributed to the OV plot where these species experienced an insignificant decline possibly due to more immigration into the plot as evidenced by significant differences in diversity indices pre and post campus development. It is reasonable to speculate that the infrastructure development elsewhere on campus had a positive effect on immigration to this parkland plot. In the undisturbed OP plot their populations remained stable, where constant immigration has likely maintained species composition and population also evidenced by significant differences in diversity indices. This was not observed in the CS plot suggesting that immigration was not a major factor in determining diversity indices because this was curtailed by infrastructure development.

These observation are consistent with faunal turnover which has been observed in avian communities on islands or in patchy environments (Wiens 1992). Since urban green spaces are fragmented (Melles et al. 2003), faunal turnover may be expected in these environments not due to immigration and colonization dynamics (Macarthur and Wilson 1967) but to rapid environment changes at the landscape level. This may be described by metapopulation theory (Hanski and Gilpin 1991). Some species may be expected to be resilient and persist, though their abundances may be reduced over time. Unless there are new sources of recruits from the surrounding landscapes, localized extirpation

might be expected (Hanski and Ovaskainen 2000). This has been observed in all plots where a majority of bird species have low abundances and are uncommon to rare (Vallejo et al. 2008, Vallejo and Aloy 2008).

Part of the landscape development of the NSC and the rest of the UP Diliman campus involves the greening of the campus by planting indigenous trees (Saloma 2012). This is being implemented in the NSC grounds and where landscaping efforts focused on planned tree planting with several areas allocated for a certain number of trees. It remains to be seen if these landscaping initiatives will favour the persistence of the resident species or allow *Passe*r and *Pycnonotus* populations to increase. However there is growing consensus among the university administration who believe it will.

CONCLUSION

Infrastructure development in the UP Diliman campus, especially in the College of Science-National Science Complex, has resulted in significant declines in population of the most common and abundant *Passer montanus* and *Pycnonotus goiaiver* species. This was not observed in the less disturbed Academic Oval and the relatively undisturbed Open Field plots in the campus. The observed decline is likely the immediate result of landscape disturbances during and right after development. While *Passer* and *Pycnonotus* may have recovered their original abundances, it is evident that highly adaptable urban species are negatively affected by urban development. While landscape enhancements may mitigate declines, it remains to be seen if planned landscape enhancements such as planting indigenous trees in the campus will allow the increase of these bird populations.

ACKNOWLEDGEMENTS

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CONFLICTS OF INTEREST

There are no conflicts of interest in this study.

CONTRIBUTIONS OF INDIVIDUAL AUTHORS

BV conceptualized the study, designed the survey design and conducted initial surveys. ABA conducted surveys and identified birds. Both authors contributed to the ecological statistical analysis of data

REFERENCES:

Brown WH. Vegetation of Philippine mountains; the relation between the environment and physical types at different altitudes. Bureau of Printing, Manila:1919:559.

Hammer Ø, Harper D, Ryan P. PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica 2001; 4(1):9.

Hanski I, Gilpin M. Metapopulation dynamics: brief history and conceptual domain.Biological Journal of the Linnean Society 1991; 42(1-2):3-16.

Hanski I, Ovaskainen O. The metapopulation capacity of a fragmented landscape. Nature 2000; 404 (6779):755-758.

Hardin G. The competitive exclusion principle. Science 1960; 131(3409):1292-1297.

Jokimäki J, Jokimäki M. Spatial similarity of urban bird communities: a multiscale approach. Journal of Biogeography 2003; 30:1183-1193.

Macarthur RM, Wilson EO. The Theory of Island Biogeography. Princeton University Press, Princeton:1967:203.

Melles S, Glenn S, Martin K. Urban Bird Diversity and Landscape Complexity: Species–environment Associations Along a Multiscale Habitat Gradient. Conservation Ecology 2003; 7(1):5.

Mikami OK. The decline in population size of the Tree Sparrow *Passer montanus* in Japan. Japanese Journal of Ornithology 2009; 58(2):161-170.

Ong P, Pedragosa M, Guia Md. Wildlife Inventory of the University of the Philippines (UP) Diliman and the Ateneo de Manila University Campus Diliman, Quezon City, Luzon, Philippines. Science Diliman 1999; 11(1):6-20.

Pinowski J, Barkowska M, Kruszewicz A, Kruszewich A. The causes of the mortality of eggs and nestlings of *Passer* spp. J Biosci 1994; 19(4):441-451.

Saloma C 2012. Memorandum No. CAS-12-038. Guidelines and Conditions for Tree Planting at UP Diliman [http://www.upd.edu.ph/~updinfo/jun12/articles/Tree%20Planting%20at%20UPD.pdf]

Sodhi NS, Sharp I. Winged Invaders - Pest Birds Of The Asia Pacific. Straits Times Press, Singapore: 2006:208.

Summers-Smith JD. A history of the status of the Tree Sparrow *Passer montanus* in the British Isles. Bird Study 1989; 36 (1):23-31.

Vallejo B, Aloy AB, Villasper J. Abundance and diversity of birds in an urban tropical landscape: The University of the Philippines campus. Science Diliman 2008; 20:1-10.

Vallejo B, Aloy AB. Estimating the rarity of birds and its ecological context in the University of the Philippines Diliman Campus. Philippine Science Letters 2008; 1(1):23-36.

Vallejo B, Aloy AB, Ong P. Distribution, abundance and diversity of birds in Manila's last greenspaces. Landscape and Urban Ecology 2009; 89:75-85.

Vincent KE. Investigating the causes of the decline of the urban House Sparrow *Passer domesticus* population in Britain. Ph.D. Thesis, De Montfort University, UK:2005:302.

Wiens JA. The Ecology of Bird Communities: Volume 2, Processes and variations. Cambridge University Press, Cambridge:1992:316