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# Bird Feeding Guild Assemblage along a Disturbance Gradient in the Pantabangan-Carranglan Watershed and Forest Reserve, Central Luzon Island, Philippines

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**Functional groups or guilds are now becoming popular in biodiversity conservation and monitoring as representative of the condition and status of a habitat as a whole. These can provide a rich source of additional evidence that can supplement evidence from studies based on taxonomic composition. In this study, we assessed differences in bird species and feeding guild assemblages across three habitat types within the Pantabangan-Carranglan Watershed and Forest Reserve (PCWFR), a major watershed in the Philippines located in the province of Nueva Ecija on central Luzon island. We sampled three habitat types during the wet and dry seasons from 2012–2016 using ground and canopy nets. After 4084 mist-net days, we captured 1191 bird individuals of 92 species and 41 families. Both species and feeding guild assemblages differed between habitats based on PERMANOVA ($p = 0.001$). Nineteen species and five feeding guilds differed in abundance between habitats. Our study demonstrated significant responses of the species and feeding guild assemblages of birds within the PCWFR to a disturbance gradient. We also found that feeding guild assemblage patterns were significantly correlated to species assemblage patterns. The use of guilds in bird monitoring can, thus, help facilitate the involvement of indigenous people and local communities, whose knowledge of birds is based on their observations of the environment, including traits that define these feeding guild classifications. However, there is potential to obscure the presence of taxonomically distinct lineages, such as the many endemic species and subspecies found on Luzon island and the Philippines. This concern is especially important in a megadiverse region like the Philippines. As such, we recommend the use of a functional approach in tandem with the traditional taxonomic approach in studying bird communities.**

Keywords: biodiversity, feeding guild, forest fragment, watershed

## INTRODUCTION

Watershed habitats are critical environments as people rely heavily on the ecosystem services they provide (McLeod *et al.* 2011). But like any other habitats, watersheds are threatened by increasing human pressures that ultimately lead to degradation and depletion of resources (Aglanu 2014). In the Philippines, watersheds play a vital role in economic development and environmental protection, as most of the remaining natural forests are located in these areas. However, around 20–40 million people, nearly one-third of the country's total population, inhabit the uplands of many watersheds, the majority of whom depend on watershed resources for survival (Lasco *et al.* 2010). As such, these watersheds are at risk from destructive

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*Corresponding Author: pabico.lemuel@gmail.com anthropogenic activities. Thus, conservation and proper management of watersheds and their nearby forests are crucial to maintaining the ecological services they provide.

Watershed resource managers need to have a defined method and strategies to gauge the impact of different management interventions in place. For example, monitoring habitat quality and ecosystem change using indicator species has become a widely used strategy among ecologists and land managers (Carignan and Villard 2002). Indicator species are organisms whose characteristics (*e.g.* presence or absence, population density, dispersion, reproductive success) are used to measure the quality of habitats being monitored (Landres *et al.* 1988).

Alternative approaches to the use of single species as indicators include the use of entire communities (Canterbury *et al*. 2000; Larsen *et al*. 2010; Fidelino *et al*. 2020) and the classification of species in the community into ecological groups, such as functional groups or guilds (O'Connell *et al.* 2000; Blaum *et al.* 2011; Kwon *et al.* 2013; Cesarz *et al.* 2015; Zanco *et al.* 2017; do Prado *et al.* 2020).

Root (1967) defined a guild as "a group of species that exploit the same class of environmental resources in a similar way" and "without regard to taxonomic position, that overlap significantly in their niche requirements." Since then, the guild concept has been interpreted and used in many ecological studies as an approach to generalize knowledge from single species. In such approaches, species with similar life strategies and traits are classified into ecological groups, such as functional types or guilds, generalizing results from individual species, and including the sensitivities of multiple species into a management decision (Blaum *et al*. 2011). For example, feeding guilds have been used as ecological groups, defined by similarities in their food resource use, foraging method, and habitat stratum use (Karr 1980; Simberloff and Dayan 1991).

Because feeding guilds are based on functional traits that define how species interact with their ecosystem, they have been used variously to supplement, test, and – in some cases – replace information based on taxonomic composition (Fountain-Jones *et al.* 2015). In fact, many recent studies have demonstrated that measures of functional traits are better predictors of ecosystem processes than measures of species diversity (Tilman *et al*. 1997; Diaz and Cabido 2001; Mouillot *et al*. 2013). In addition, the use of functional groups in ecological assessment and monitoring can ease the need for taxonomic expertise. This can help facilitate the participation of indigenous people and local communities, whose own knowledge systems are based on their observations of their natural environments, including many traits that ecological groupings are defined by (Ziembicki *et al*. 2013).

Bird taxa are among the most popular indicators for monitoring ecosystem changes for a number of reasons. Birds use a wide range of habitats, have diverse ecological niches, and occupy different trophic levels (Eglington *et al*. 2012; Alexandrino *et al*. 2017). Bird taxonomy is also relatively stable, and extensive data are widely available for many species (Eglington *et al*. 2012), including a comprehensive guidebook to Philippine birds (Kennedy *et al*. 2000). Compared to other faunal groups, birds are also more readily sampled – for example, through observational transects or through direct capture using mist nets (O'Connell *et al.* 2000).

Bird composition and diversity can be influenced by vegetation structure, foraging substrates, and availability and abundance of food (MacArthur and MacArthur 1961; Holmes *et al.* 1979). They are also influenced by disturbance, as some bird species can tolerate moderate to a high degree of disturbance, while some are easily extirpated if a disturbance is introduced in their natural habitat (Kurosawa 2009). Because different bird species have different food and foraging microhabitat preferences, they can be classified into various feeding guilds. The presence, absence, and abundance or rarity of these feeding guilds have been used to classify different habitat and disturbance gradients, as well as the condition of habitats where they are present (Holmes *et al.* 1979; Holmes and Recher 1986; Wielstra *et al.* 2011; Mansor and Sah 2012).

In this study, we used mist nets to sample birds in three areas representing the mosaic of habitats of varying degrees of disturbance within the PCWFR in central Luzon, Philippines. We assessed differences in bird species and feeding guild assemblage between three vegetation types representing a disturbance gradient within the PCWFR – secondary forest fragment (FF), forest plantation (FP), and wooded grassland (WG). We asked three main questions:

(1) How do the bird species and feeding guild assemblages respond to the disturbance gradient we sampled in the PCWFR?

(2) Does the feeding guild assemblage respond in the same way as the species assemblage to the disturbance gradient in the PCWFR?

(3) Which bird species and feeding guilds, if any, showed a positive or negative response to the disturbance gradient?

## MATERIALS AND METHODS

### Study Area

The PCWFR lies between 15°44’ to 16°88’ N and 120°36’ to 122°00’ E and is bounded on the north, northwest, and northeast by the Caraballo Mountain Range and on the south, southeast, and southwest by the Sierra Madre Mountain Range (Figure 1). It is located in the province of Nueva Ecija on central Luzon island. The climate in the study area is classified under Climatic Type I of the corona classification, characterized by two distinct seasons – the dry season occurs from December–April, while the wet season occurs for the rest of the year (Lasco *et al.* 2010).

The PCWFR is one of the most important watersheds in the country as it houses one of the largest dams that generate electricity providing power supply in most parts of central Luzon (Peras *et al.* 2008). The major land types present in the watershed are forests, open grasslands, and reforestation sites (Lasco *et al.* 2010). Patches of forest are located in the ravines and gullies. The largest FF is located in Mt. Maluyon, northwest of the reservoir, with an elevation reaching 800 masl. Several disturbances can be observed in the surrounding area of the watershed such as slash-and-burn farming, illegal cutting of trees, and grazing of domesticated livestock (NPC 2017). Parts of the PCWFR are under the certificate of ancestral domain claims of the Bugkalots, Kalanguya, and Kankanaey – indigenous people belonging to the Igorot tribe of the Cordilleras (Gojo Cruz *et al*. 2018).

Three study sites were selected based on their vegetation structure and general characteristics: secondary FF, FP, and WG. The secondary FF is the most intact habitat, while the WG experiences the heaviest disturbance among the three. These include agricultural farming, human settlement, occasional wildfire, animal grazing, and human disturbances brought by a road that also cuts through the FP.

***Site 1.*** The FF on Mount Maluyon, with its peak at 15°52’28.74” N 121°03’57.08” E and an elevation of 790 masl, is generally characterized as an isolated secondary lowland dipterocarp forest of about 2 km$^2$. *Anisoptera thurifera*, *Shorea contorta*, *Mangifera monandra*, *Tarrietia sylvatica*, and *Diplodiscus paniculatus* comprise the emergent trees in the area. The undergrowth is composed mainly of *Cinnamomum mercadoi*, *Dimocarpus* spp., *Calophyllum* spp., *Camellia lanceolata*, *Syzygium*

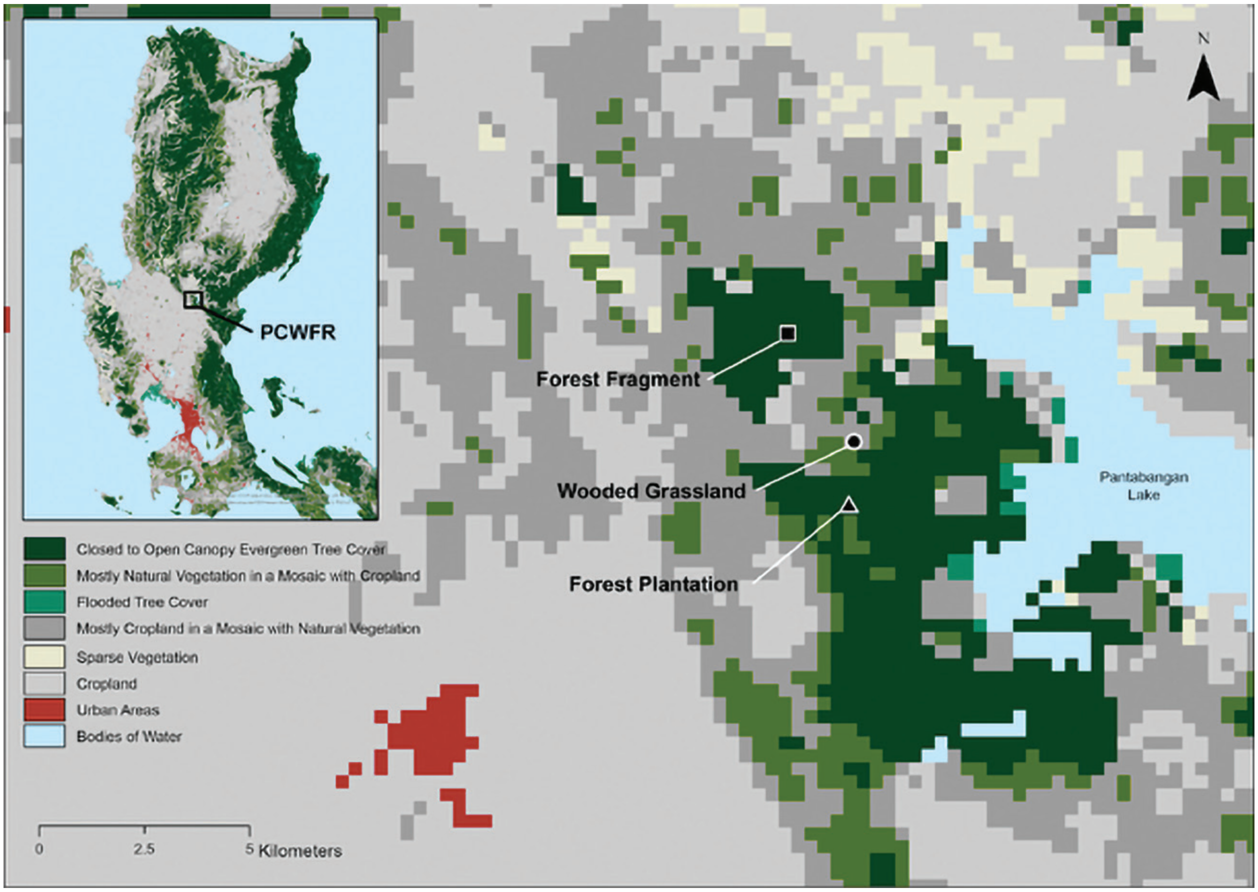

**Figure 1.** Location of the study areas within the PCWFR in central Luzon island, Philippines.

spp., and *Lithocarpus* spp. with saplings dominated by *C. lanceolata.* It is one of the few mountains surrounding the watershed with intact forest. Disturbances in the area are mostly hunting activities by the local community and occasional tree cutting.

***Site 2.*** The FP on Mount Balukbok – located at 15˚50'23.42" N 121 ˚04'43.98" E, 321 masl – is a 30-year-old reforestation site planted with *Gmelina arborea*, *Albizia saman*, *Leucaena leucocephala*, and *Mangifera indica*. The site is located along the ridge with patches of bamboo and abandoned slash-and-burn farms. Aside from the planted trees, other tree species observed in the area include *Vatica mangachapoi*, *Celtis luzonica*, *Diplodiscus paniculatus*, *Tarrietia sylvatica*, *Maranthes corymbosa*, *Shorea guiso*, *Palaquium* sp., and *Aglaia* sp. Canopy vines observed in the study site include *Piper* and *Connarus* spp. Hunting, firewood extraction, and an access road that is used by the community to transport crops are common disturbances encountered in the area.

***Site 3.*** The WG site is located on one of the foothills of Mt. Maluyon and is currently designated as a reforestation area. The site is characterized by open grassland with small patches of shrubs and trees. It lies at 15˚51'08.8" N 121˚04'48.1" E, 338 masl. The vegetation in the area is composed mainly of *Eucalyptus deglupta*, *A. saman*, *L. leucocephala*, *Bauhinia malabarica*, *Tectona grandis*, and *Nauchea orientalis*. Grasses and shrubs include *Imperata cylindrica*, *Lantana camara*, *Paspalum conjugatum*, *Saccharum spontaneum*, and *Pennisetum purpureum.*

### Bird Sampling

Bird surveys through mist-netting were undertaken from 2012–2016 as part of the biodiversity conservation and monitoring program in the watershed. Sampling was conducted twice every year to monitor possible changes and shifts in species diversity and composition between seasons. Dry season surveys were conducted every February and March while wet season surveys were conducted every October and September. Eight sampling occasions, four each during the wet and dry seasons, were undertaken during the five-year study. Seasonal sampling was conducted to take into account possible seasonal variability in bird abundance.

Fifteen to 20 mist nets (length: 12 m; 36 mm mesh size) were set on the ground as series of five nets placed along ridges and trails with regular intervals from each other in each site. In addition, two sets of three and two nets – vertically placed above each other, respectively – were raised on the subcanopy through the use of a pulley system (Ingle 1993). Mist nets were operated for nine days on each site, transferring them every three days to a different location within the area to avoid familiarity of the species and increase capture rate. Nets were checked every hour for possible captures. Captured individuals were identified following Kennedy and colleagues (2000), measured (total length, weight, bill, wing, and tarsus length), tagged, and released. Taxonomy was updated based on the latest checklist of Philippine birds released by the Wild Bird Club of the Philippines (Jensen *et al*. 2020). Birds were tagged using numbered aluminum ring bands placed on their right tarsus.

Capture and handling of birds were conducted in accordance with guidelines to the use of wild birds in research published by the Ornithological Council (Fair *et al.* 2010). The permission to conduct the research was covered by the Department of Environment and Natural Resources (DENR) Gratuitous Permit numbers III-2011-02, III-2013-02, III-2014-02, and III-2016-03.

### Feeding Guild Designation

Classification of birds as to their feeding guild was done *a priori* using expert knowledge and previous observations based on published literature (Johns 1986; Gonzalez 1995; Gonzalez and Dans 1997; Kennedy *et al.* 2000; Styring *et al.* 2011; Wilman *et al*. 2014). We primarily followed the feeding guild classification by Gonzalez (1995) and Gonzalez and Dans (1997). Feeding guild classification of bird species was based on their trophic group (*e.g.* insectivore, frugivore, nectarivore, piscivore), foraging layer (*e.g.* arboreal or terrestrial), and foraging habits or methods (*e.g.* bark-gleaning, foliage-gleaning, sallying, sweeping, raptorial) (Gonzalez and Dans 1997). In cases where no literature was found on the foraging habit of certain species, we classified them based on their nearest relative species. The species were categorized into 16 feeding guilds (Table 1; Appendix I).

### Statistical Analyses

We compared bird composition between the three sampled habitats within the PCWFR at two levels – using species assemblage data and using feeding guild assemblage data. In both cases we used bird capture rates pooled per sampling period (*e.g.* wet season of 2013) as an indicator of local abundance, presuming there is a close correlation between capture rates and the number of birds inhabiting or foraging a given habitat (Duya *et al.* 2017). For the analyses at the feeding guild level, we pooled bird capture data into their respective feeding guilds, also per sampling period. We removed 14 bird species that are migratory from the dataset prior to analyses to prevent biases brought by the seasonal influx of migrants in the study area.

First, we log(x+1) transformed data to meet statistical assumptions and avoid skewness (Iwata *et al.* 2003; Kurosawa 2009). We then used permutational multivariate

**Table 1.** Number of representative species for each feeding guild sampled in the three habitat types of the PCWFR.

| Code | Feeding guild | Total | FF | FP | WG |
|---|---|---|---|---|---|
| AF | Arboreal frugivore | 10 | 4 | 9 | 5 |
| AI | Arboreal insectivore | 1 | 1 | 1 | 1 |
| AIF | Arboreal insectivore-frugivore | 10 | 4 | 7 | 4 |
| BGI | Bark-gleaning insectivore | 7 | 5 | 4 | 4 |
| FF | Faunivore/frugivore | 1 | 0 | 1 | 0 |
| FGI | Foliage-gleaning insectivore | 15 | 6 | 7 | 11 |
| IN | Insectivore/nectarivore | 1 | 0 | 1 | 1 |
| MIP | Miscellaneous insectivore/piscivore | 2 | 0 | 1 | 2 |
| R | Raptorial | 6 | 2 | 6 | 3 |
| SaI | Sallying insectivore | 10 | 6 | 7 | 5 |
| SR | Semi-raptorial | 3 | 2 | 2 | 3 |
| SSI | Sallying/sweeping insectivore | 1 | 0 | 1 | 1 |
| SwI | Sweeping insectivore | 5 | 3 | 3 | 2 |
| TF | Terrestrial frugivore | 7 | 0 | 3 | 6 |
| TI | Terrestrial insectivore | 11 | 3 | 7 | 8 |
| TIF | Terrestrial insectivore-frugivore | 2 | 0 | 1 | 2 |

analysis of variance (PERMANOVA) to compare species assemblage and feeding guild assemblage between habitat types. PERMANOVA allows analysis of data with few assumptions and flexibility in the multivariate analysis of ecological data (Anderson 2001). It uses pseudo-F statistics and *p*-values from permutation tests in providing quantitative measures for the effect of factors in nonparametric data (Curtis *et al.* 2016). We used the Bray-Curtis Dissimilarity index for the PERMANOVA analysis (function "adonis") in the Community Ecology Package ("vegan" 2.5-6) (Oksanen *et al.* 2019) of the R statistical software (R Core Team 2020). The Bray-Curtis Dissimilarity Index has been found to have a robust monotonic and linear relationship with ecological distance and is widely employed in multivariate analysis of assemblage data (Faith *et al.* 1987; Clarke *et al.* 2006). Habitat type was used as a factor in the analysis with 999 permutations at $\alpha = 0.05$. We also performed the same analyses with sampling season and habitat type + sampling season as factors but did not find sampling season as a significant factor. As such, we dropped sampling season as a factor in subsequent analyses.

To visualize the results of the PERMANOVA, we used nonmetric multidimensional scaling (NMDS) using the function "metaMDS" of "vegan" to construct two-dimensional ordination plots. An NMDS ordination plot places sampling sites on an *n*-dimensional space with essentially arbitrary axes, where the distance between points is a measure of similarity (Kenkel and Orloci 1986). We constructed NMDS plots using Bray-Curtis distance matrices as input to visualize differences in species assemblage and feeding guild assemblage between habitats. We also overlaid the NMDS scores of the feeding guilds to visualize the relationship of these guilds to the sampled habitats.

Next, we tested whether patterns of differences between habitats based on feeding guild assemblage data were significantly associated with patterns based on species assemblage data. We compared the species-level NMDS ordination and the feeding guild-level NMDS ordination using a Procrustes test with 999 permutations with the "protest" function of "vegan" in R (Peres-Neto and Jackson 2001; Rader *et al*. 2014). This method performs permutations of symmetric Procrustes analyses to estimate the statistical significance of matric resemblance between the compared ordinations (Oksanen *et al*. 2019).

Lastly, we assessed which species and feeding guilds showed significant differences between the sampled habitats and, if any, which showed significant responses to the disturbance gradient. We performed Kruskal-Wallis tests on species and feeding guild capture rates with habitats as groups, and *post hoc* pairwise analyses between groups showing significant differences. Kruskal-Wallis tests were performed in IBM SPSS Statistics for Windows v 20.0 (2011). Lastly, we constructed box-and-whisker plots of mean capture rates of the species and feeding guilds that showed significant differences between habitats.

## RESULTS

A total of 1191 individuals from 92 species and 41 families were recorded after 4084 net-days of sampling. Of the 92 species, 13 are migratory with 208 individuals, while the rest are Philippine residents. Despite the fragmented nature of the forest in the watershed, 43 Philippine endemics and four near-endemics were observed. These include *Erythrura viridifacies* listed as vulnerable by the IUCN and three near-threatened birds – *Mulleripicus funebris*, *Ficedula disposita*, and *Otus longicornis.* The families Muscicapidae and Columbidae have the greatest number of species with eight representative species each (see Appendix I).

The birds sampled in the PCWFR were classified into 16 feeding guilds. The foliage-gleaning insectivore (FGI) guild has the highest number of representative species (15); followed by the terrestrial insectivore (TI) guild with 11 species; and the arboreal frugivore (AF), arboreal insectivore-frugivore (AIF), and sallying insectivore (SAL) guilds, all of which have 10 representative species (Table 1).

Species richness was highest in the FP with 61 species, followed by the WG with 58; the FF has the least number of species with 36. Overall bird abundance was highest in the WG where 526 individuals were captured, and lowest in the FF with 250 captured individuals. A total of 415 individuals were captured in the FP.

All 16 feeding guilds were observed in the FP, 15 in the WG, and 10 in the FF. The most abundant feeding guild in the FP and WG was the AIF guild with 100 and 191 individuals, respectively. TIs were the most abundant guild in the FF with 78 individuals.

### Bird Assemblages along the Disturbance Gradient

We found significant differences between habitats in both species assemblage (F = 8.97, $p = 0.001$) and feeding guild assemblage (F = 8.50, $p = 0.001$). The constructed NMDS plots for both the species assemblage (stress = 0.13) and feeding guild assemblage data (stress = 0.13) reflect this (Figure 2). In both plots, the disturbance gradient can be observed distinctly along the NMDS1 axis from the FF to the FP to the WG sampling points. However, the NMDS plots show that clustering of sampling points within the same habitat and separation from points from the other habitats were more pronounced in the species assemblage plot.

Overlaying the NMDS scores of each feeding guild on the guild assemblage plot revealed that TIs are associated with the FF; FGI and AF with the FP; and SSI, TF, and AIF with the WG. The IN and SR guilds were not associated with any habitat based on the NMDS.

### Bird Abundances along the Disturbance Gradient

Nineteen species were significantly different between each habitat based on Kruskal-Wallis tests. Among these, 13 species belong to the aforementioned guilds; the remaining species belong to the FGI, SaI, or SwI guilds (Figure 3). Of the 19 species, only three species displayed a negative response to the disturbance gradient – the TIs *Actenoides lindsayi* and *Copsychus luzoniensis* and the SAL *Rhipidura cyaniceps*; all three are Philippine endemics.

Of the 16 feeding guilds, five were found to have significant differences in abundance between habitats based on Kruskal-Wallis tests. These were AF, AIF, R, TF, and TI (Figure 4). However, *post hoc* pairwise analyses showed different responses of these feeding guilds to the disturbance gradient. The AIF guild displayed increasing abundance from the least (FF) to the most disturbed habitat (WG), while the TI guild displayed the opposite pattern. On the other hand, abundance peaked at the FP for the AF, R, and TF guilds.

## DISCUSSION

### Use of Mist Nets in Bird Monitoring

Mist netting has several advantages over visual and aural bird survey techniques, especially in studies that involve long-term monitoring. It can sample species that other methods detect poorly, such as ground-foraging birds, secretive species, and those that vocalize infrequently (Dunn and Ralph 2004). Counts and identification are also not subject to observer bias and, especially in long-term monitoring, allows the changing of personnel without the risk of introducing observer-based variability in detection. Netting effort is more easily standardized than visual and aural surveys. Mist netting also allows direct examination of all birds sampled and the collection of additional morphometric and population data, including samples for other research purposes such as parasite loads and DNA samples (Ralph *et al*. 1993; Dunn and Ralph 2004).

With our bird monitoring spanning five years from 2012–2016, we found a significant advantage in sampling standardization in mist-netting over line transects, which we also conducted concurrently to our mist net sampling. We found it difficult to ensure the availability of the same observers for the line transects over five years, and so inevitably introduced detection rate and identification biases from different observers. In contrast, detection and identification of birds using mist nets was more consistent, as it always involved direct handling and photography of all captured birds, with a comprehensive reference guide

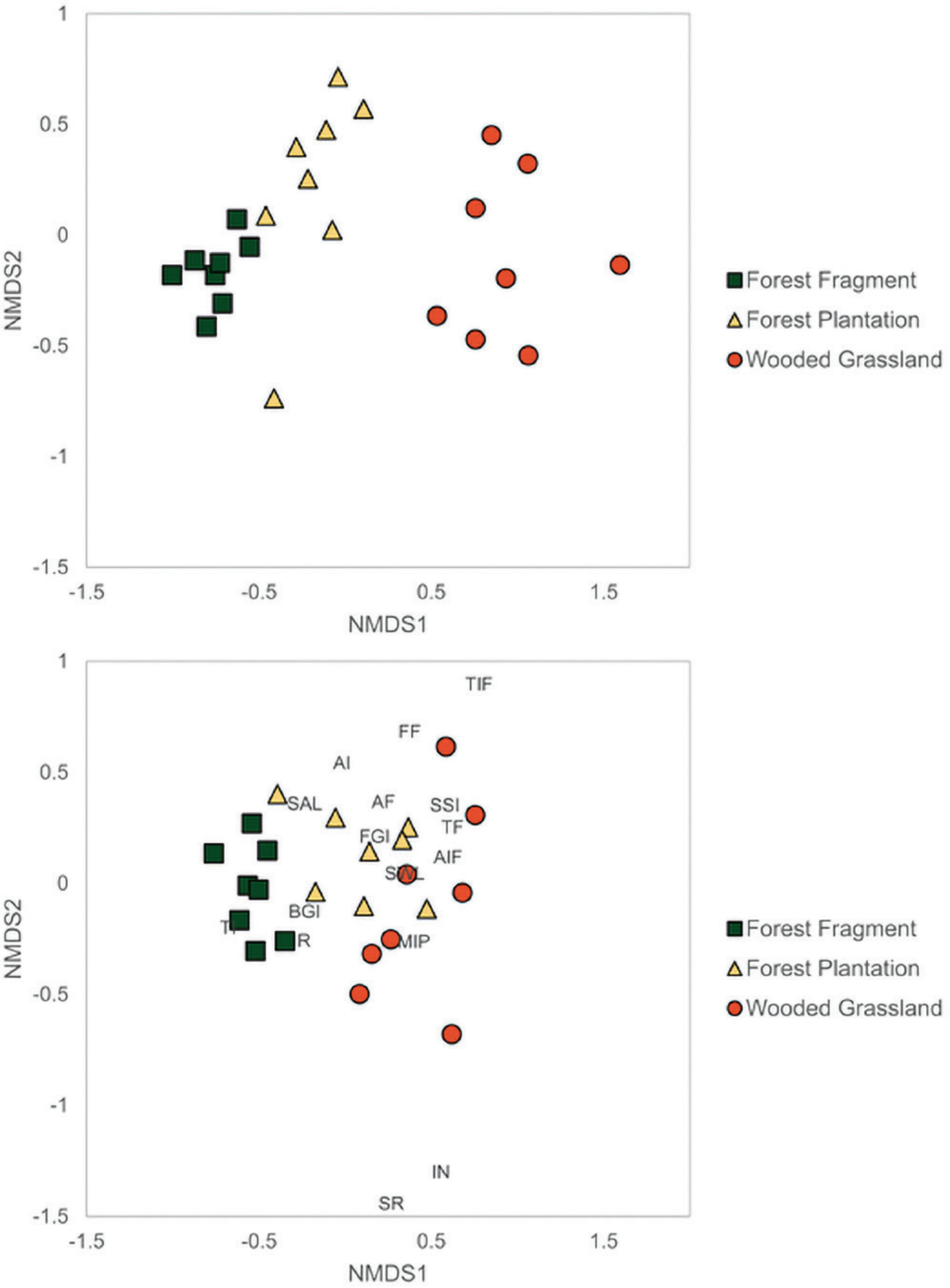

**Figure 2.** NMDS plots based on log-transformed capture data of bird species assemblage (stress = 0.13) and feeding guild assemblage (stress = 0.13) in the PCWFR, Central Luzon island, Philippines. Refer to Table 1 for feeding guild notations.

book at hand. Mist netting also facilitated the participation of members of the local community that we employed as local guides, who we trained to assist in the operation of nets and in the identification of captured birds.

However, compared to visual and aural surveys, mist-netting is more time-intensive and also requires specialized training in net operation and bird processing. As it involves direct handling of birds, mist netting should be employed by personnel with adequate knowledge in operation and care of nets, safe and ethical handling of birds, and procedures for obtaining permits (Ralph *et al*. 2004). In addition, mist-netting is also often less efficient in terms of detection rate per unit effort (Dunn and Ralph 2004). It also under-samples some species groups, such as raptors and aerial foraging birds, especially without the use of canopy nets (Wang and Finch 2002). Increased netting on the same site, as conducted in long-term monitoring can also induce net avoidance (Ralph *et al*. 2004).

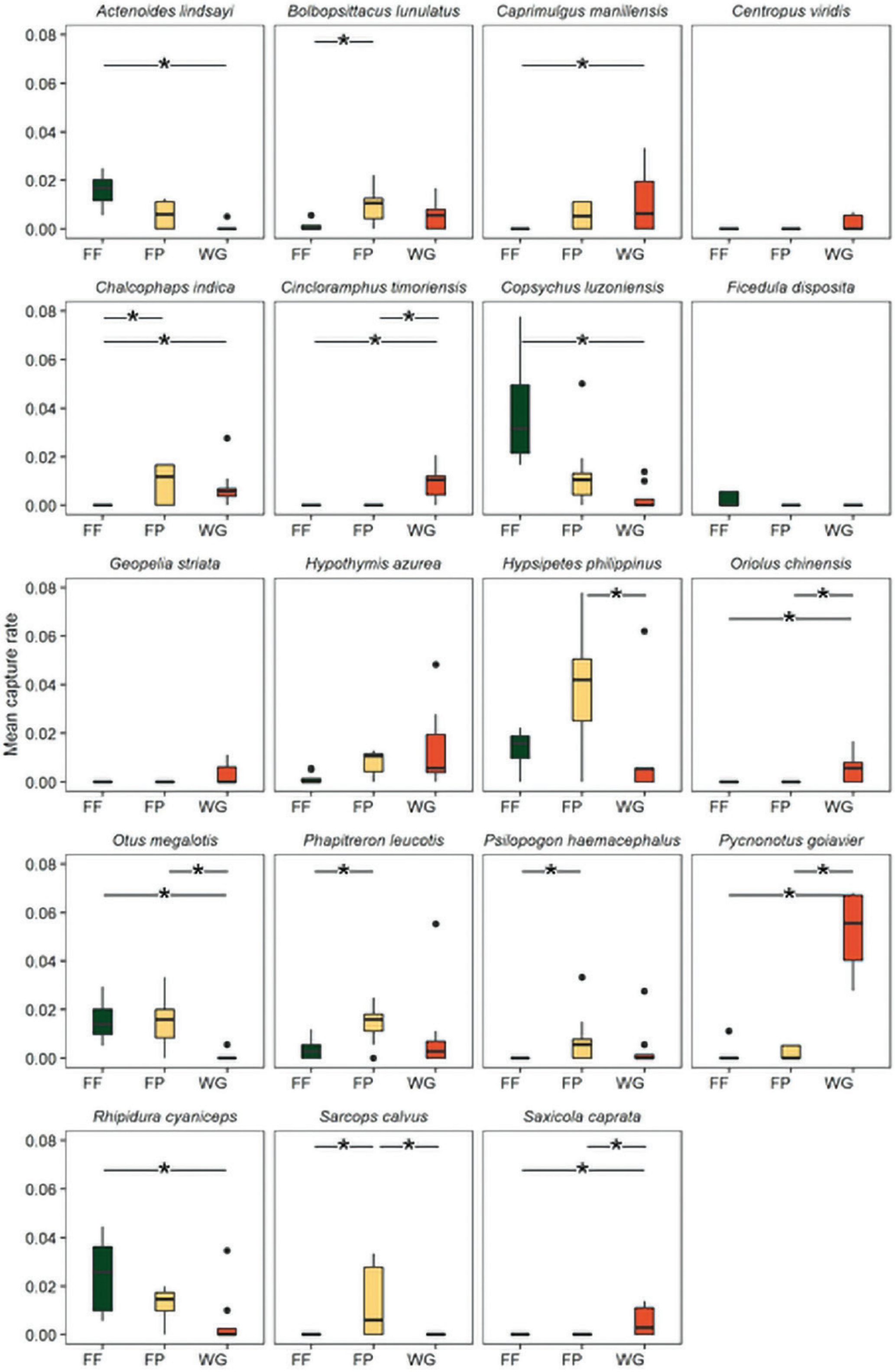

**Figure 3.** Box-and-whiskers plots of differences in mean capture rates (per mist net-day) of bird species between three habitat types in the PCWFR, Central Luzon island, Philippines. Asterisks denote significant pairwise differences ($\alpha = 0.05$) after global Kruskal-Wallis tests ($p < 0.05$). Filled points are outliers. FF – forest fragment, FP – forest plantation, WG – wooded grassland.

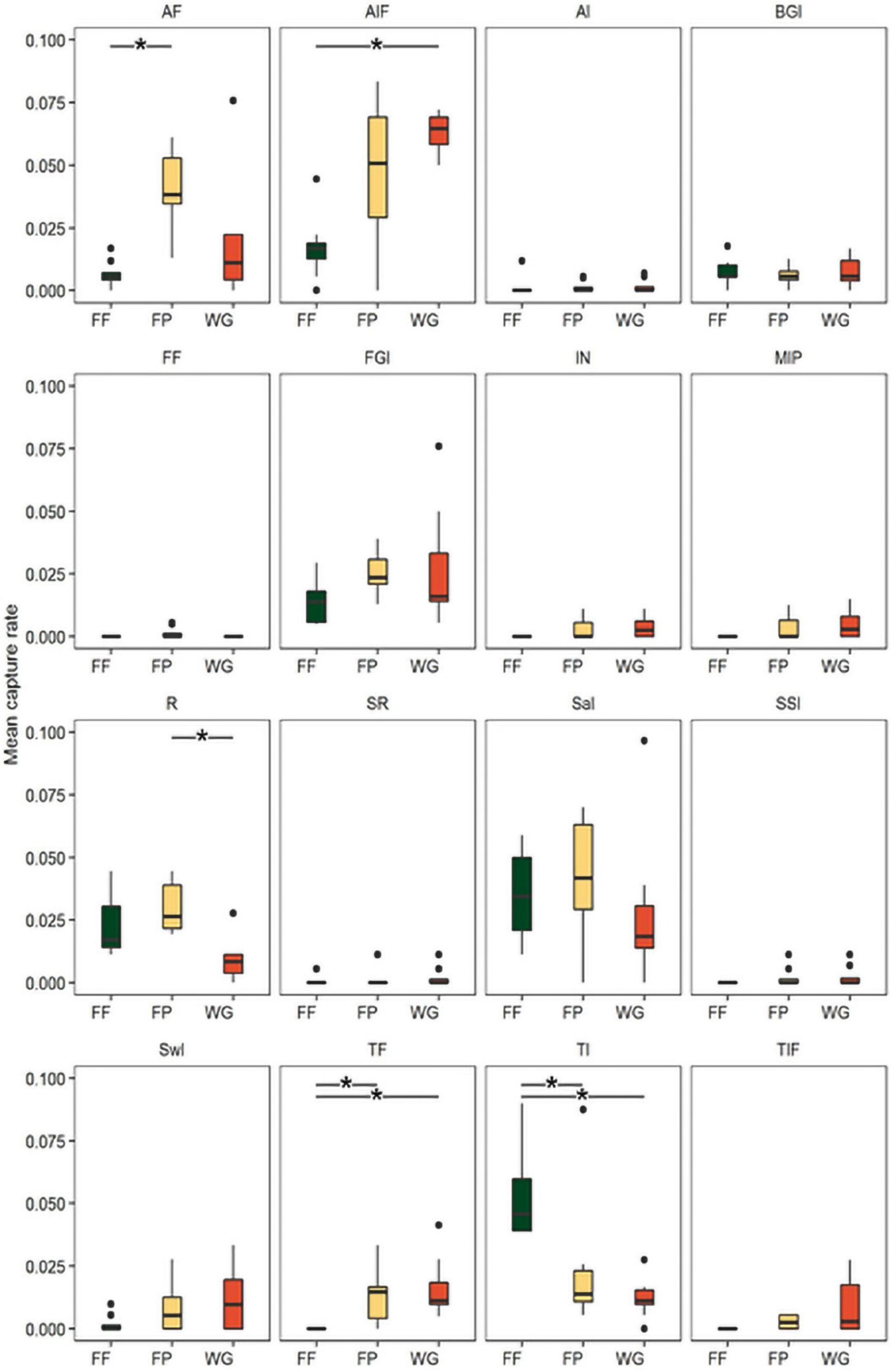

**Figure 4.** Box-and-whiskers plots of differences in mean capture rates (per mist net-day) of feeding guilds between three habitat types in the PCWFR, Central Luzon island, Philippines. Asterisks denote significant differences (α = 0.05). Filled points are outliers. FF – forest fragment, FP – forest plantation, WG – wooded grassland. Refer to Table 1 for feeding guild notations.

From the combined counts from both mist-netting and line transects, we have recorded 141 bird species – a total of 49 species recorded through visual and aural surveys were not captured in mist nets (data not presented). Indeed, these included several raptor species but also several species of large doves, coucals, sunbirds, flowerpeckers, and tailorbirds. It appears that the mesh size of the nets we employed allowed smaller birds to escape sampling more readily, as in the case of the sunbirds, flowerpeckers, and tailorbirds we failed to capture. In general, species from these three groups belong, respectively, to the insectivore-nectarivore, AF, and FGI guilds. While we observed high capture rates for the AF and FGI guilds based on representative species we were able to capture, we had lower capture rates for the IN guild. It is, thus, possible that we have undersampled this guild and, consequently, that mist-netting must be supplemented with other sampling methods to more appropriately compare the abundances of these guilds between habitat types.

A combination of mist net sampling and point transects may prove to be a more comprehensive method of assessment and monitoring, provided that differences in detection rates and sampling effort between these methods are considered when analyzing collected data. Nonetheless, evaluation studies have found good correspondence between mist netting-derived abundances and independently derived data on the same targets (*i.e.* point counts at the same location) (Dunn and Ralph 2004).

### Species and Feeding Guild Occurrences

The total number of birds observed in the study represents 13% (92) of the total species recorded in the Philippines (709) (Jensen *et al*. 2020). The observed endemic species also represent 18% of the total Philippine endemics. Moreover, the observed species represent 18% of the species found in Luzon (LePage 2019). The FP and the WG habitat in our study have more diverse feeding guild assemblages compared to the FF. Omnivores such as the yellow-vented bulbul (*Pycnonotus goiavier*) and black-naped oriole (*Oriolus chinensis*) were the most common species in the FP and WG; these species are associated with disturbed habitats (Kennedy *et al.* 2000). A similar pattern was also observed in the different habitats in Sikkim, India, where they found a positive relationship of omnivores in more disturbed and open habitats (Chettri *et al.* 2001).

We have also recorded greater species richness in the FP (61) and WG (58) than the FF (36). The pattern is similar to studies elsewhere where greater avian diversity was found at intermediate levels of disturbance, *e.g.* suburban areas (Jokimaki and Suhonen 1993; Blair 1996; Verma and Murmu 2015). The diversity of feeding guilds and high species richness observed in the WG and FP sites is consistent with the intermediate disturbance hypothesis (Connell 1978), in that recurrent disturbances prevent communities in these areas from reaching equilibrium, as well as disrupt competitive processes between species to allow coexistence of several species.

### Species Assemblage Responses to Disturbance

We found a significant difference in the species assemblage of birds between the three habitat types sampled in the PCWFR. The constructed NMDS plot reflects the influence of the disturbance gradient on the bird assemblage in our study area, indicating that the composition of birds in the FF and WG are most different, with the FP between them. However, the sampling design only included three habitat types; a wider disturbance gradient will likely provide more information on the degree of the observed bird assemblage response.

This response of the bird community to a disturbance gradient is evidence of the group's utility as an indicator of habitat quality and ecosystem health in Philippine forests. Posa and Sodhi (2006) have demonstrated that the community composition of birds in forests within the Subic Bay Watershed Reserve – also on Luzon island – was distinct from those in suburban, rural, and urban areas impacted by human disturbance. Similarly, in a gradient of human-modified habitats on Mindanao island – from agroforest to rice fields, roads, and heavily disturbed areas – birds showed a significant difference in species composition (Tanalgo *et al*. 2015). On Palawan island, Mallari and colleagues (2011) also observed responses of individual species to a disturbance gradient. In particular, they identified species which were strongly associated with old-growth forests. However, they also recorded species with the highest densities in each of the other habitats along the gradient sampled.

In our study, we recorded three species that showed a pattern of abundance decrease from the most intact to the most disturbed habitat. All three are insectivores and endemic to the Philippines – *Actenoides lindsayi*, *Copsychus luzoniensis*, and *Rhipidura cyaniceps*. On the other hand, we recorded three species that showed the opposite response to the disturbance gradient. *Oriolus chinensis*, *Pycnonotus goiavier*, and *Saxicola caprata* were all significantly most abundant in the WG and showed significant decreases in abundance from there to the FP, and then to the FF. Lastly, we also recorded species that showed peak abundance at the intermediate level of disturbance (*i.e.* in the FP). These are *Bolbopsittacus lunulatus*, *Chalcophaps indica*, *Hypsipetes philippinus*, *Otus megalotis*, *Phapitreron leucotis*, *Psilopogon haemacephalus*, and *Sarcops calvus*.

It will be interesting to identify the specific aspects of the habitats that drive individual species' preferences, as has been done by Mallari and colleagues (2011) and Posa and Sodhi (2006). These may include the abundance of food resources and the presence of habitat features that act as microhabitats, nests, or foraging areas (*i.e.* tree holes, dense undergrowth, sufficient canopy, large trees) (Holmes *et al.* 1979; Gray *et al.* 2007; Mammides *et al.* 2015).

### Feeding Guild Responses to Disturbance

We also found a significant difference in bird feeding guild assemblage between habitat types within the PCWFR. Similar to the pattern observed in the NMDS plot of species assemblage, the feeding guild assemblage of birds responded to the disturbance gradient. In addition, we found that the community similarity pattern from the feeding guild-level data was significantly correlated to the community similarity pattern from the species-level data.

In addition, we found that the TI guild responded negatively to disturbance. This may reflect selective habitat use and restricted ability to cross open areas and move between FFs (Martensen *et al.* 2012; Sreekar *et al.* 2015; Godoi and De Souza 2016). Two of the three species we found to have a negative response to the disturbance gradient are TIs (*A. lindsayi* and *C. luzoniensis*). On the other hand, the AIF guild was found to increase in abundance along the disturbance gradient. Representative species of this guild include *O. chinensis* and *P. goiavier*, species known to be tolerant of human disturbances.

Our results, thus, demonstrate that feeding guild-level data can also be sensitive to the effects of disturbance on the bird community. However, visual inspection of the NMDS plots reveals that the degree of community differences between the three habitat types decreased slightly with the shift to feeding guild-level data, as evidenced by the closer positioning of samples compared to the species assemblage NMDS plot (Figure 2). This may be evidence of the reduction in the information that comes with a reduced level of detail when using feeding guilds instead of species. Functional approaches such as the use of feeding guilds have been utilized widely in other countries in assessing habitat quality, ecosystem health, and human disturbance in natural systems (Canterbury *et al*. 2000; O'Connell *et al.* 2000; Alexandrino *et al.* 2017; Arruda Almeida *et al.* 2018). However, such an approach runs the risk of obscuring significant taxonomic information, especially in a megadiverse region like the Philippines. For example, we recorded 43 Philippine endemics and four near-endemics within the PCWFR in this study. While a purely functional approach might provide stronger predictions about ecosystem processes compared to a taxonomic approach, the resulting conclusions will not take into consideration the value inherent to taxonomically unique lineages.

Our study was motivated by the increased recognition that functional diversity, rather than taxonomic diversity, is a stronger predictor of ecosystem functioning (Diaz and Cabido 2001) and the response of ecological communities to disturbance (Mouillot *et al.* 2013). While we have used feeding guilds as surrogate groups to represent functional diversity, gathering species into such groups has been noted to result in the loss of information and the imposition of discrete categories on functional differences between species, which are usually continuous (Villeger *et al.* 2008). Future studies should thus utilize a framework that utilizes continuous measures of functional diversity using quantitative values for functional traits. Such indices of functional diversity based on quantitative functional traits have been published in the past two decades, such as functional richness, functional evenness, and functional divergence (Mason *et al.* 2005; Mouillot *et al*. 2013). We recommend the use of such a framework in future studies, as it might be able to provide more information on the functional diversity of bird assemblages in the watershed.

## CONCLUSION

Our study demonstrated significant responses of the species and feeding guild assemblages of birds within the PCWFR to a disturbance gradient. We also identified particular species and feeding guilds that show significant patterns of increase and decrease along the disturbance gradient. These can be explored further as avenues to utilize bird communities as indicators of ecosystem health in watershed ecosystems.

Local communities usually identify birds based on their observations of behavior in the wild such as during nesting, foraging, and feeding. Because the designation of bird species into feeding guilds are based on such observed behavior, the use of guilds in monitoring changes in the environment can help facilitate the involvement of local communities as a form of community science and can be a cost-effective supplement to taxonomy-based monitoring.

While we found that feeding guild assemblage patterns were significantly correlated to species assemblage patterns, there is a potential loss of information with an approach that is fully based on functional traits. In particular, it will obscure the presence of taxonomically distinct lineages, such as the many endemic species and subspecies found on Luzon island and the Philippines. This concern is especially important in a megadiverse region like the Philippines. As such, we recommend the use of a functional approach in tandem with the traditional taxonomic approach in studying bird communities.

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## NOTES ON APPENDICES

The complete appendices section of the study is accessible at http://philjournsci.dost.gov.ph

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# APPENDICES

**Appendix I.** All bird species recorded in PCWFR with their respective family, IUCN Red List status (2020-2), residency status, and feeding guild classification. Feeding guild classifications followed Gonzalez (1995), Gonzalez and Dans (1997), and Wilman *et al.* (2014).

| Species name | Common name | IUCN Red List status[a] | Residency status[b] | Feeding guild |
|---|---|---|---|---|
| **Caprimulgidae** | | | | |
| *Caprimulgus manillensis* | Philippine nightjar | LC | E | SwI |
| *Lyncornis macrotis* | Great eared nightjar | LC | R | SwI |
| **Apodidae** | | | | |
| *Collocalia marginata* | Grey-rumped swiftlet | LC | E | SwI |
| **Cuculidae** | | | | |
| *Cacomantis sepulcralis* | Rusty-breasted cuckoo | LC | R | FGI |
| *Centropus viridis* | Philippine coucal | LC | E | FGI |
| *Dasylophus cumingi* | Scale-feathered malkoha | LC | E | AIF |
| *Dasylophus superciliosus* | Rough-crested malkoha | LC | E | AIF |
| *Hierococcyx pectoralis* | Philippine hawk-cuckoo | LC | E | FGI |
| *Hierococcyx sparverioides* | Large hawk-cuckoo | LC | M | FGI |
| *Surniculus velutinus* | Philippine drongo-cuckoo | LC | E | FGI |
| **Columbidae** | | | | |
| *Chalcophaps indica* | Common emerald dove | LC | R | TF |
| *Geopelia striata* | Zebra dove | LC | R | TF |
| *Macropygia tenuirostris* | Philippine cuckoo-dove | LC | NE | AF |
| *Phapitreron amethystinus* | Amethyst brown dove | LC | E | AF |
| *Phapitreron leucotis* | White-eared crown dove | LC | E | AF |
| *Ptilinopus occipitalis* | Yellow-breasted fruit dove | LC | E | AF |
| *Streptopelia tranquebarica* | Red turtle dove | LC | R | TF |
| *Treron axillaris* | Philippine green pigeon | LC | E | AF |
| **Rallidae** | | | | |
| *Gallirallus torquatus* | Barred rail | LC | R | TIF |
| **Turnicidae** | | | | |
| *Turnix ocellatus* | Spotted buttonquail | LC | E | TIF |
| **Accipitridae** | | | | |
| *Accipiter gularis* | Japanese sparrowhawk | LC | M | R |
| *Accipiter soloensis* | Chinese sparrowhawk | LC | M | R |
| *Accipiter virgatus* | Besra | LC | R | R |
| **Tytonidae** | | | | |
| *Tyto longimembris* | Eastern grass owl | LC | R | R |
| **Strigidae** | | | | |
| *Ninox philippensis* | Luzon hawk-owl | LC | E | R |
| *Otus longicornis* | Luzon scops owl | NT | E | AI |
| *Otus megalotis* | Philippine scops owl | LC | E | R |
| **Trogonidae** | | | | |
| *Harpactes ardens* | Philippine trogon | LC | E | AIF |
| **Bucerotidae** | | | | |
| *Penelopides manillae* | Luzon hornbill | LC | E | FF |

| Species name | Common name | IUCN Red List status[a] | Residency status[b] | Feeding guild |
|---|---|---|---|---|
| **Alcedinidae** | | | | |
| *Actenoides lindsayi* | Spotted wood kingfisher | LC | E | TI |
| *Halcyon coromanda* | Ruddy kingfisher | LC | R,M | MIP |
| *Halcyon smyrnensis* | White-throated kingfisher | LC | R | MIP |
| **Meropidae** | | | | |
| *Merops viridis* | Blue-throated bee-eater | LC | R | SSI |
| **Megalaimidae** | | | | |
| *Psilopogon haemacephalus* | Coppersmith barbet | LC | R | AIF |
| **Picidae** | | | | |
| *Chrysocolaptes haematribon* | Luzon flameback | LC | E | BGI |
| *Dryocopus javensis* | White-bellied woodpecker | LC | R | BGI |
| *Mulleripicus funebris* | Sooty woodpecker | NT | E | BGI |
| *Yungificus maculatus* | Philippine pygmy woodpecker | LC | E | BGI |
| **Falconidae** | | | | |
| *Microhierax erythrogenys* | Philippine falconet | LC | E | SR |
| **Psittaculidae** | | | | |
| *Bolbopsittacus lunulatus* | Guaiabero | LC | E | AF |
| *Loriculus philippensis* | Philippine hanging parrot | LC | E | AF |
| **Pittidae** | | | | |
| *Erythropitta erythrogaster* | Philippine pitta | LC | NE | TI |
| *Pitta sordida* | Hooded pitta | LC | R | TI |
| **Campephagidae** | | | | |
| *Edolisoma coerulescens* | Blackish cuckooshrike | LC | E | AIF |
| *Lalage nigra* | Pied triller | LC | R | FGI |
| *Pericrocotus divaricatus* | Ashy minivet | LC | M | FGI |
| **Pachycephalidae** | | | | |
| *Pachycephala albiventris* | Green-backed whistler | LC | E | SaI |
| *Pachycephala philippinensis* | Yellow-bellied whistler | LC | E | SaI |
| **Laniidae** | | | | |
| *Lanius cristatus* | Brown shrike | LC | M | SR |
| *Lanius schach* | Long-tailed shrike | LC | R | SR |
| **Oriolidae** | | | | |
| *Oriolus chinensis* | Black-naped oriole | LC | R | AIF |
| **Dicruridae** | | | | |
| *Dicrurus balicassius* | Balicassiao | LC | E | SaI |
| **Rhipiduridae** | | | | |
| *Rhipidura cyaniceps* | Blue-headed fantail | LC | E | SaI |
| **Monarchidae** | | | | |
| *Hypothymis azurea* | Black-naped monarch | LC | R | SaI |
| *Terpsiphone cinnamomea* | Rufous paradise flycatcher | LC | NE | SaI |
| **Paridae** | | | | |
| *Pardaliparus elegans* | Elegant tit | LC | E | FGI |

| Species name | Common name | IUCN Red List status[a] | Residency status[b] | Feeding guild |
|---|---|---|---|---|
| **Pycnonotidae** | | | | |
| *Hypsipetes philippinus* | Philippine bulbul | LC | E | AIF |
| *Pycnonotus goiavier* | Yellow-vented bulbul | LC | R | AIF |
| **Hirundinidae** | | | | |
| *Hirundo rustica* | Barn swallow | LC | M | SwI |
| *Hirundo tahitica* | Pacific swallow | LC | R | SwI |
| **Phylloscopidae** | | | | |
| *Phylloscopus cebuensis* | Lemon-throated leaf warbler | LC | E | FGI |
| **Locustellidae** | | | | |
| *Cincloramphus timoriensis* | Tawny grassbird | LC | R | FGI |
| *Helopsaltes fasciolatus* | Gray's grasshopper warbler | LC | M | FGI |
| *Helopsaltes ochotensis* | Middendorff's grasshopper warbler | LC | M | FGI |
| *Megalurus palustris* | Striated grassbird | LC | R | FGI |
| **Cisticolidae** | | | | |
| *Cisticola exilis* | Golden-headed cisticola | LC | R | FGI |
| *Orthotomus chloronotus* | Trilling tailorbird | LC | E | FGI |
| **Zosteropidae** | | | | |
| *Zosterops nigrorum* | Yellowish white-eye | LC | E | AIF |
| **Sittidae** | | | | |
| *Sitta oenochlamys* | Sulphur-billed nuthatch | LC | E | BGI |
| **Sturnidae** | | | | |
| *Rhabdornis grandis* | Grand rhabdornis | LC | E | BGI |
| *Rhabdornis mystacalis* | Stripe-sided rhabdornis | LC | E | BGI |
| *Sarcops calvus* | Coleto | LC | NE | AIF |
| **Turdidae** | | | | |
| *Turdus obscurus* | Eyebrowed thrush | LC | M | TI |
| **Muscicapidae** | | | | |
| *Copsychus luzoniensis* | White-browed shama | LC | E | TI |
| *Copsychus mindanensis* | Philippine magpie-robin | LC | E | TI |
| *Cyornis rufigastra* | Mangrove blue flycatcher | LC | R | SaI |
| *Eumyias panayensis* | Turquoise flycatcher | LC | R | SaI |
| *Ficedula disposita* | Furtive flycatcher | NT | E | SaI |
| *Calliope calliope* | Siberian rubythroat | LC | M | TI |
| *Muscicapa griseisticta* | Grey-streaked flycatcher | LC | M | SaI |
| *Saxicola caprata* | Pied bush chat | LC | R | TI |
| **Dicaeidae** | | | | |
| *Dicaeum australe* | Red-keeled flowerpecker | LC | E | AF |
| *Dicaeum pygmaeum* | Pygmy flowerpecker | LC | E | AF |
| *Dicaeum trigonostigma* | Orange-bellied flowerpecker | LC | R | AF |
| **Nectariniidae** | | | | |
| *Cinnyris jugularis* | Olive-backed sunbird | LC | R | IN |

| Species name | Common name | IUCN Red List status[a] | Residency status[b] | Feeding guild |
|---|---|---|---|---|
| **Estrildidae** | | | | |
| *Erythrura viridifacies* | Green-faced parrotfinch | VU | E | TF |
| *Lonchura atricapilla* | Chestnut munia | LC | R | TF |
| *Lonchura leucogastra* | White-bellied munia | LC | R | TF |
| *Lonchura punctulata* | Scaly-breasted munia | LC | R | TF |
| **Motacillidae** | | | | |
| *Anthus gustavi* | Pechora pipit | LC | M | TI |
| *Anthus hodgsoni* | Olive-backed pipit | LC | M | TI |
| *Motacilla cinerea* | Grey wagtail | LC | M | TI |

[a] IUCN Red List status: LC – least concern, VU – vulnerable, NT – near threatened
[b] Residency status: M – migrant, R – resident, E – endemic, NE – near-endemic