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Research Article

Avifauna composition and communities in Leyte Sab-a Basin Peatland and its vicinity in Northeastern Leyte, Philippines

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Abstract

Leyte Sab-a Basin Peatland (LSBP) is one of the two confirmed peatlands in the Philippines threatened by land-use conversion and degradation. No published study has investigated the degradation of LSBP and its impact on the species diversity of the avian community. We conducted a rapid assessment of bird presence in the four sites (Alangalang, Sta Fe, San Miguel, and Tacloban). Species richness data were measured based on a combination of transect walks, opportunistic listing, acoustic surveys, and vantage point observation in forest edges and inside the LSBP areas. Secondary data were collated from different literature, websites, and available publications to form a unified field checklist of avifauna. We recorded 67 avifauna species from 37 families/other taxa. The highest species richness was recorded in Alangalang (41) and Sta Fe (40), followed by San Miguel and Tacloban with 33 and 26 species. We recorded 18 endemics, five threatened, and 13 migratory bird species. Principal Coordinates Analysis (PCoA) revealed a high degree of dissimilarity in beta diversity among sites. Avian species that are under a threatened category and are Key Biodiversity Area trigger species: Blue-naped Parrot (*Tanygnathus lucionensis*), Rufous Hornbill (*Buceros hydrocorax*), Philippine Duck (*Anas luzonica*), Philippine Hanging-parrot (*Loriculus philippensis*), and Azure-breasted Pitta (*Pitta steerii*). LSBP harbored a significantly high number of avian species, thus, their ecological role in terms of habitat refuge and breeding ground for migratory, forest-dependent, threatened, endangered, and critically endangered species and endemics should not be disregarded. The strict protection zone should be established first, especially on the last remaining untouched areas of the peatland, while enhancing the vegetation of those affected ones.

Keywords: Critically Endangered, endemic, Key Biodiversity Area, Leyte Sab-a Basin Peatland, trigger species

Introduction

Peatland ecosystems harbor a unique variety of biological communities across the hierarchical level of an ecosystem (Minayeva et al., 2017). However, the significance of peatlands as a habitat for diverse biological species has often been neglected because of their unique environmental conditions compared to other ecosystem types (Minayeva & Sirin, 2012). This arises because peatlands acquire energy and material flow via long-term storage within a peat layer, forming biological entities that cannot be found elsewhere (Minayeva & Sirin, 2012; Minayeva et al., 2017). Biodiversity is maintained by different climatic factors, ecological processes, and human interference in the peatland environments that can be expected to interact differently. Hence, the distinctive benefits of peatlands to a variety of life forms have been underestimated in both research and conservation efforts (Minayeva et al., 2017).

In Southeast Asia, the significance of tropical peat swamp forests for biodiversity is gaining attention globally (Ramji et al., 2016). Data on species information within peatland habitats are scarce, limiting the development of conservation and monitoring strategies for protection from human activities (Husson et al., 2018). In the Philippines, LSBP is one of the identified ecosystems with significant peatland deposits. The LSBP has a substantial area of peat swamp forest and the most critical water catchment basin in the Visayas, receiving water from springs, rivers, aquifers, and rainfall (ADB, 2000). With a lack of or limited knowledge about the ecological importance of peat swamp forest, there have been numerous human interventions done in the 1970’s to convert LSBP into agricultural land. The conversion and draining of the peatland may have resulted in its degradation characterized by the loss of important species of flora and fauna, alterations to the physicochemical properties of peat soil, and other impacts on ecological services (ADB, 2000; Decena et al., 2021). Only 2,107.64 hectares remain as peatland in Sab-a Basin (Garcia et al. in press). The peatland plays a significant role in carbon storage, biodiversity conservation, and ecosystem services for surrounding communities and the entire province (Harrison & Rieley, 2018; Lehmitz et al., 2020).

Birds serve as an integral component of the environment because they are bioindicators of ecosystem health and climate change (Ayodeji & Kilishi, 2019; Şekercioĝlu et al., 2012). The distribution, diversity, and abundance of birds are dependent on the landscape features, e.g., types of habitats, food resource availability, and season (McIntyre, 1995; Ali & Mushtaq, 2021). Avifauna provides numerous ecological functions, such as agents of seed dispersal, pollinators of many plants, regulators of pests by consuming insects and rode,nts and may facilitate the restoration of forest ecosystems (Philpott et al., 2009; Şekercioĝlu et al., 2012;

Maas et al., 2015; Tanalgo et al., 2015). Studies have shown that high avian diversity can exist in adverse environmental conditions of the peatland ecosystem (Schrevel, 2008; Mohd Azmi et al., 2009).

The remaining forest in LSBP is threatened by various anthropogenic stressors, from mono-crop agriculture, road widening, quarrying, agricultural land conversion, reclamation, slash and burn, exotic tree plantation, and rampant illegal hunting that could significantly affect the biodiversity of the peatland. Despite the importance of LSBP as a carbon sink, climate regulation, and habitats to diverse wildlife species, no published ornithological studies have focused on this unique ecosystem. The inclusion of LSBP in the proposed local conservation area and other legal frameworks may greatly help the survival of the threatened species and migratory bird species that are more dependent on the peatland as their habitat.

The general objective of this study was the assessment of the avifaunal species assemblage and its conservation status in different sites within LSBP and its vicinity. Specifically, this paper aims to i) assess and compare the composition and diversity of avifauna species in different sites within LSBP and its vicinity with mixed land use and vegetation types (Alangalang, Sta Fe, San Miguel, and Tacloban City); and ii) determine the presence of avian species with high ecological value and conservation status that may be impacted due to the emerging ecological threats in the LSBP. Our research is the first published study in the Leyte region on avifauna species composition and diversity in LSBP.

Materials and methods

Study area

Recent estimates of LSBP suggest that the peatland has an area of about 2,107.64 hectares (Garcia et al. in press; Table 1). The peatland is in the northeastern part of Leyte Island, close to Tacloban City, with geographic coordinates of N11.23234 latitude and E124.90932 longitude. The peatland covers the municipalities of Alangalang, Sta. Fe, and San Miguel.

The LSBP is characterized by Tacloban Ophiolite Complex (TOC) on the eastern side. The underlying geology of the peatland comprised the depressional portions of the broad alluvial plain of the province of Leyte derived from ultramafic rocks and sedimentary sequences (ADB, 2000; Suerte et al., 2005). Soil formation in the central portion of the Sab-a basin is mainly Dolongan peat. The soil has been mineralized around the edges of LSBP due to erosion from the surrounding watershed, which deposited mineral soil at the foot of the ridges. The western portion of the basin is categorized as Palo clay/loam (ADB, 2000). There are two river systems from the western flank, Bangon or Palo River and Mainit River, supplying water from this area while surface runoff from the mountainous northern and eastern sides. In the central and southern portions, three natural physical barriers prevent the water from flowing into the inner portion of the peatland (Garcia et al. in press).

The highest elevation is 17 masl, where the LSBP crosses the two watershed boundaries of the two river systems. It is near Tabangohay, Alangalang, Leyte, with N11.26 latitude and E124.90 longitude coordinates. The lowest elevation is 12 masl, located near San Isidro, Sta Fe, Leyte, with a distance of 7.2 km from the highest point or a slope of 0.069%. The elevation of the lowest point of LSBP along the Sangputan river near Tabangohay, Alangalang, Leyte is approximately 11 masl with a distance of 2.2 km from the highest point or a slope of 0.27% (Garcia et al. in press).

Leyte region is classified under Cluster 1 climate with the heaviest rainfall in December, with median, and mean rainfall values of >400 mm. The minimum rainfall occurs in April with both median and mean values of 150 mm (Corporal-Lodangco & Leslie, 2017). Wet and dry seasons are not distinct throughout the year, so discussing wet and dry seasons is not meaningful.

Sampling sites

Alangalang

A large portion of the peat swamp forest is located in the northern and central parts of the peatland in barangays Tabangohay and Divisoria, comprising 410.00 and 291.54 hectares, respectively (Table 1, Fig. 1). It is characterized by dominant tree species *Terminalia copelandii*, *Nauclea orientalis*, and *Metroxylon sagu*. Other vegetation types present in the area were grasses and sedges, cultivated crops, and pools with hydrophytes.

Sta Fe

Most vegetations are grasses and sedges mainly observed in Barangay San Isidro (167.66 ha; Table 1, Fig. 1). The dominant vegetation recorded were *Scleria scobiculata*, *Fimbristylis globulosa*, and *Cyperus trachysanthos*. Some portions of the area were abandoned rice fields due to poor yield. There are also cultivated root crops grown in some areas like *Alocasia macrorhizuz*.

San Miguel

The area is characterized by having mixed vegetation types. A significant portion of the peat swamp forest is located in barangay Guinciaman with 148.11 hectares (Table 1). Barangay Capilihan is primarily grasses and sedges with *Fimbristylis globulosa* as the dominant plant species.

Tacloban City

The sampling area is along the road edges, dominated by various trees, grasses, and sedges. Abandoned farmlands were also evident in the area.

Table 1. General land use and vegetation found in Leyte Sab-a Basin Peatland (Garcia et al. in press).

		General Land use and Vegetation					
Municipality	Barangay	Peat Swamp Forest	Grasses and Sedges	Grasses and Sedges (with cultivation)	Pools with hydrophytes	Total Area per Barangay	Total Area per Municipality
Sta Fe	Gapas	8.41	12.97	23.51	34.76	79.65	329.66
	San Isidro	39.32	167.66	18.29	24.71	250.01	
Alangalang	Divisoria	291.54	242.19	40.67	8.16	582.57	1383.13
	Langit	0.05	22.43	26.68	43.26	92.41	
	Tabangohay	410.00	4.46	65.75	0.00	480.21	
	Veteranos	39.80	101.00	57.99	29.15	227.94	
San Miguel	Capilihan	1.29	145.95	28.07	5.61	180.92	394.85
	Guinciaman	148.11	55.09	0.43	10.30	213.93	
General Land use/Vegetation Total		938.52	751.75	261.385	155.95	Total Peatland Area	2,107.64

Data collection

The avifaunal assessment was carried out from March 31 to April 9, 2021. There were 29 sampling points distributed across the sites (Fig. 1). We also noted the presence of avifauna species along the road in Tacloban City, characterized by various species of trees, sedges, grasses, and abandoned farmlands. Transect walks, opportunistic samplings, and vantage point observation was employed on forest edges and inside the peatland areas. Avifauna assessment was conducted by traversing the study sites from 6:00 – 10:00 AM and 115:00 – 18:00 Direct observation of species encountered on the study sites was listed, including identification, type of observation (visual and/or acoustics), photography, and important notes. Acoustic surveys were also done to complement the methods, focally on cryptic bird species. Species unencountered areas not covered within study sites we also added to the species list and noted as a general observation, especially for disturbed areas.

Notable species encountered during the survey were geotagged and photographed for documentation purposes. Ethnobiological interviews were also conducted before the field survey. Using maps and the images of threatened wildlife species we obtained in the literature, we interviewed the locals about any additional known locations or potential sightings of our target species. Secondary data from different literature, websites, and available publications were collated to form a unified field checklist of avifauna. Gratuitous Permit (GP No. 2021-06) was secured in coordination with DENR-Region 8 before data collection.

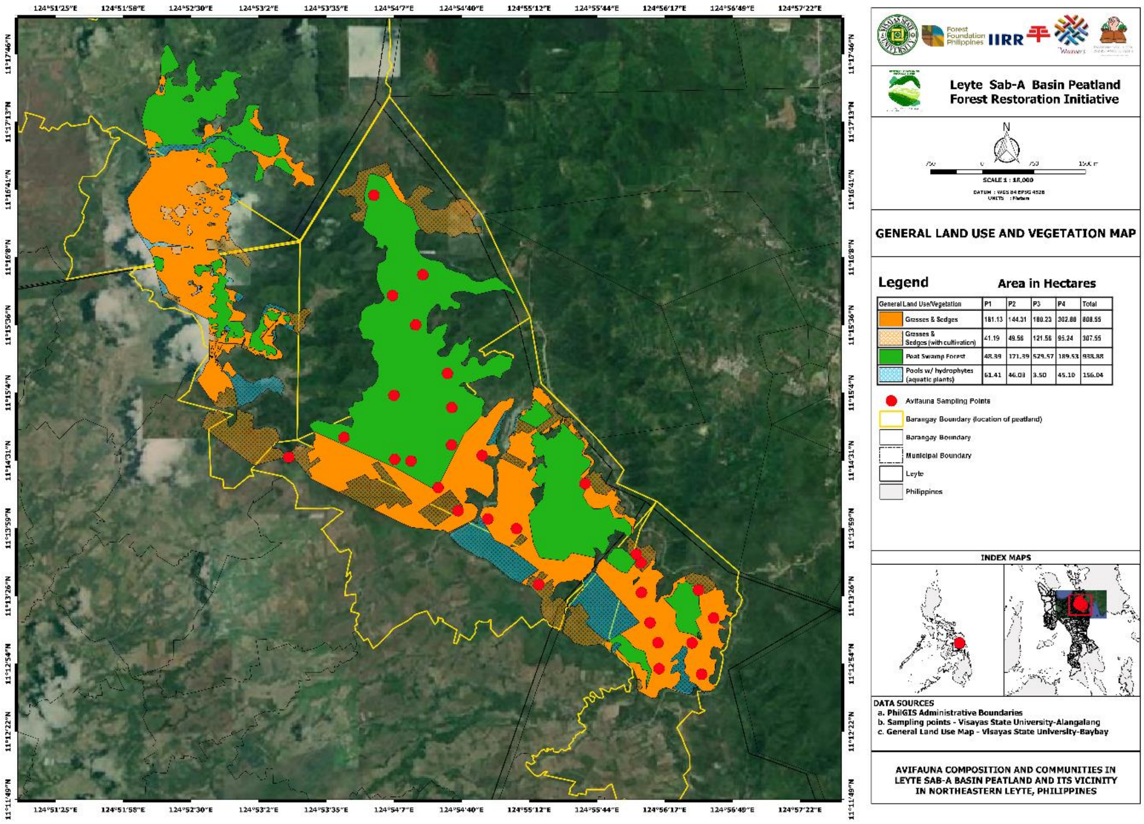

Figure 1. Sampling sites for avifauna assessment across various land use and vegetation types in the Leyte Sab-a Basin Peatland.

For the checklist, we narrowed down the list by selecting only the locality of Leyte. We conferred with e-bird life (https://ebird.org) for the avifauna of Leyte. We referred to the IUCN Red List of Threatened Species (https://www.iucnredlist.org) and the Philippine Red list of the Department of Environment and Natural Resources (DENR-DAO 2019-09) as local equivalents for its conservation status. We also used several published guides on birds of the Philippines to aid us in the endemicity and species distribution of avifauna assemblage (Kennedy et al., 2000; Strange, 2013; Jakosalem et al., 2019) and e-bird (https://ebird.org/about) for avifauna checklist of Leyte Island. The publication on the biodiversity baseline assessment in Southern Leyte was used as secondary data for birds (Mallari et al., 2013).

Data analysis

Avian species richness was calculated to determine the number of species present in the four sampling sites. The similarity/dissimilarity of species composition was assessed by comparing the Jaccard dissimilarity coefficient using the presence/absence equivalent in avifauna communities across the four sites. Avifauna data apply presence/absence scores (1-present, 0-absent). The dissimilarity of sites within themselves and between other sites was calculated. This operation produces six dissimilarity values that display changes in avifauna community composition across the sites. Similarity Percentages (SIMPER) analysis, based on the Jaccard dissimilarity metric was used for identifying which species contribute most to beta diversity between sites. Principal coordinates analysis (PCoA) was applied to the dissimilarity matrices among sites to generate a compositional ordination with the Jaccard dissimilarity index (Ricotta et al., 2016). Jaccard dissimilarity index, SIMPER, and PCoA were performed using the vegan package in R version 4.1.2 software (Dixon, 2003; Oksanen et al., 2019; R Core Team, 2021).

Results

A total of 67 avifauna species belonging to 37 families were documented across the four sampling sites (Table 2). Alangalang and Sta Fe comprised the highest number of species with 41 and 40 respectively, while San Miguel and Tacloban recorded 33 and 26 avian species (Fig. 2). Ardeidae (bitterns, egrets, and herons) had the most significant number of species (10), followed by Rallidae (crakes and rails) and Columbidae (pigeons and doves) with five species. The rest of the families had fewer species.

Based on the calculated Jaccard index values, there was a high degree of dissimilarity in beta diversity among sites. The highest computed Jaccard index scores were between San Miguel and Tacloban (79.6%), Sta Fe and Tacloban (73.1%), and Alangalang and San Miguel (70.2%). The comparison between Alangalang and Tacloban had 66% dissimilarity while Sta Fe and San Miguel and Alangalang and Sta Fe had Jaccard index values of 56.9% and 55.4%, respectively. The cumulative percent contribution of each species to Jaccard dissimilarity between each pair of sites is shown in Table S1. The first and second ordination axes of PCoA, based on avifauna communities, explained respectively 50.5% and 31.3% of the total variation (Fig. 3). These axes mainly explained the high degree of dissimilarity in terms of species composition of avifauna along with the four studied sites.

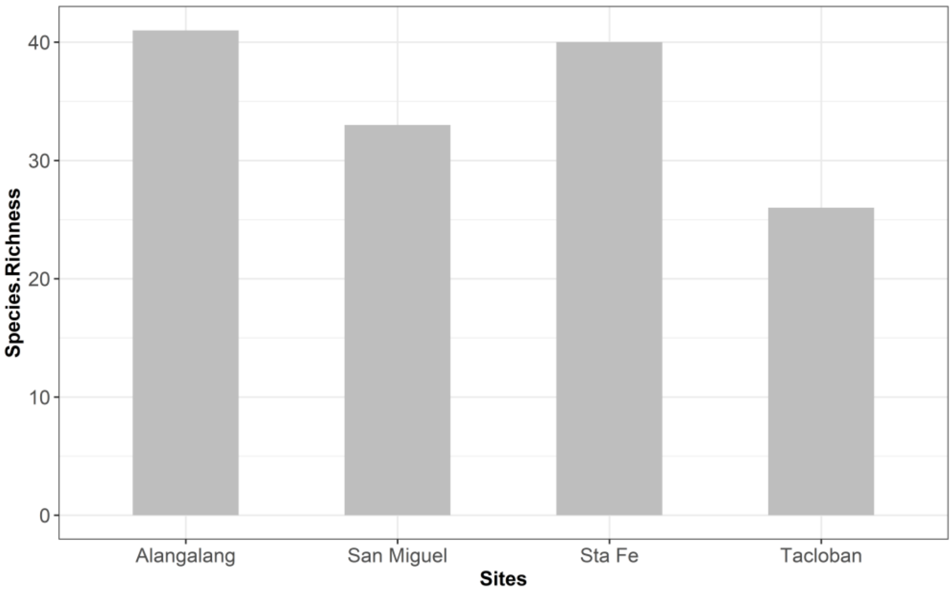

Figure 2. Species richness of avifauna communities in Leyte Sab-a Basin Peatland and its vicinity.

Of 67 bird species, 18 are Philippine endemic, with five threatened species and 13 migratory birds. Several avian species in the peatland are under a threatened category and are Key Biodiversity Area (KBA) trigger species. Blue-naped Parrot (*Tanygnathus lucionensis*) is a Philippine near-endemic classified as a Near Threatened species under IUCN and Critically Endangered species under DENR DAO 2019-09 and PCSD 15-521. It is also a CITES-listed species. It is widespread throughout the country and is found in secondary forests and plantations of up to 1000 masl, nesting in tree holes (BirdLife International, 2022). Although confined in the Philippines, there were records that high densities of Blue-naped parrot were documented in Karakelang, Talaud Islands, Indonesia, and islands off north-east Borneo, Malaysia (Collar et al., 1999; Riley, 2003). It primarily feeds on seeds and some fruits, acting as seed dispersers for these plants (BirdLife International, 2022). A flock of this bird species was observed nesting in a tree hole of Toog (*Petersianthus quadrialatus*), competing with the oriental dollar bird (*Eurystomus orientalis*). This is also the first geographical record of the Bue-naped parrot in Eastern Visayas.

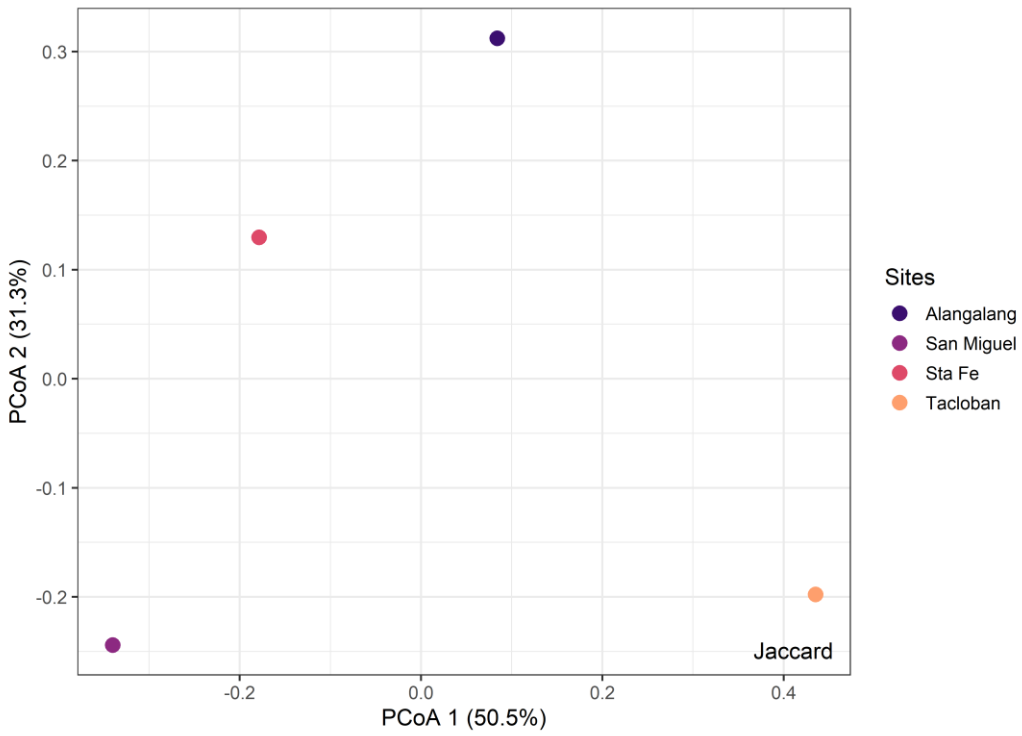

Figure 3. Principal coordinates ordination of avifauna species' presence/absence scores based on the Jaccard index.

Rufous Hornbill (*Buceros hydrocorax*) is endemic to the Philippines, where it occurs in the primary, mature secondary, and disturbed forests on 11 islands: Luzon and Marinduque (race *hydrocorax*), Samar, Leyte, Bohol, Panaon, Biliran, Calicoan, and Buad (race *semigaleatus*), Dinagat, Siargao, Mindanao (plus Balut, Bucas, and Talicud) and Basilan (race *mindanensis*). This forest-dependent species has been classified as Vulnerable on IUCN red list and Endangered Category under DAO-2019-09. Hornbills are keystone species in the forest because they serve as integral components of ecosystem functioning and resiliency for their feeding habit as omnivores. In the food web, they are fruit eaters, agents of seed dispersal, and predators of various insect pests. These birds are regarded as “Farmers of the Forest” (Trisurat et al., 2013; Naish, 2015). This species was observed in Brgy. Tabangohay during the actual survey but was not captured in photos. Records and ethnobiological interviews with residents and key informants also confirmed the presence of this bird on the forest edge of peatland.

Philippine Duck (*Anas luzonica*) is the country’s only endemic duck classified as Vulnerable under IUCN, DENR AO 2019-09, and PCSD 15-521. These ducks are observed frequently in freshwater and saltwater habitats, including mangroves, open sea, and watercourses inside the forest. Feeding guild wise, it forages on fish, shrimps, insects, rice, and young vegetation. Like other ducks and waterfowls, it plays a crucial role in keeping wetland plant communities diverse and healthy (Carboneras & Kirwan, 2020).

The long-tailed Shrike (*Lanius schach*) is found widely distributed across Asia. Although it is not listed under DAO-2019-09 and the IUCN red list, it is classified as Vulnerable species under PCSD 15-521. It usually thrives in an open country with scrub, light woodland, cultivated areas, and grasslands with scattered bushes. It is a very opportunistic predator acting like a small raptor, which helps regulate the population of its prey items. It primarily feeds on insects and other vertebrates such as small mammals, lizards, frogs, crabs, and small birds (Yosef et al., 2020). The chin, throat, and upper breast are white, while the rest of the underparts are rufous. Its wings are blackish with a white wing-spot conspicuous in flight. This species was observed in open grasslands in the midstream portion of the watershed. The Philippine hanging Parrot (*Loriculus philippensis*) is Critically Endangered status under DAO-2019-09. It is the smallest parrot in the Philippines that is mainly found in all forest types, including montane forest. There were also sightings in urban areas, mostly in green environments in the cities. This is the first record of the occurrence of this species in the peatland ecosystem. The distinguishing feature of this bird is the red color on its head and rump. It feeds on nectars of flowers, mainly from coconuts and bananas (Senarillos et al., 2021).

Azure-breasted Pitta (*Pitta steerii*) is a Philippine endemic bird, where is known in Samar, Leyte, Bohol, and Mindanao (BirdLife International, 2001). It is classified as Vulnerable under DAO-2019-09 and the IUCN red list. There is no published literature on the presence of this species in the peatlands in the Philippines. Its ecology, distribution, and population are poorly known. The population of pitta is small and heavily fragmented and declining owing to the habitat loss in lowland forests (BirdLife International, 2022).

Table 2. Avifauna species were recorded in the Leyte Sab-a Basin Peatland and its vicinity.

Family	Common Name	Scientific Name	Sites				Conservation Status	
			Alangalang	Sta Fe	San Miguel	Tacloban	IUCN	DAO 2019-09
Charadriidae	Lesser Sand-Plover	*Charadrius mongolus*	1	1	0	1	LC	-
Scolopacidae	Marsh Sandpiper	*Tringa stagnatilis*	1	0	1	0	LC	-
Acanthizidae	Golden-bellied Gerygone	*Gerygone sulphurea*	1	1	1	0	LC	-
Campephagidae	Pied Triller	*Lalage nigra*	0	1	0	1	LC	-
Oriolidae	Black-naped Oriole	*Oriolus chinensis*	1	0	1	0	LC	-
Artamidae	White-breasted Woodswallow	*Artamus leucorynchus*	1	1	1	1	LC	-
Rhipiduridae	Philippine Pied-Fantail	*Rhipidura nigritorquis* (a)	1	1	1	1	LC	-
Laniidae	Brown Shrike	*Lanius cristatus*	1	1	1	0	LC	-
Laniidae	Long-tailed Shrike	*Lanius schach*	1	1	0	1	LC	-
Corvidae	Large-billed Crow	*Corvus macrorhynchos*	1	1	1	0	LC	-
Cisticolidae	Rufous-fronted Tailorbird	*Orthotomus frontalis* (a)	0	0	1	1	LC	-
Cisticolidae	Golden-headed Cisticola	*Cisticola exilis*	0	1	1	0	LC	-
Estrildidae	Scaly-breasted Munia	*Lonchura punctulata*	1	1	1	1	LC	-
Estrildidae	Chestnut Munia	*Lonchura atricapilla*	1	1	1	1	LC	-
Passeridae	Eurasian Tree Sparrow	*Passer montanus*	1	1	1	1	LC	-
Anatidae	Wandering Whistling-Duck	*Dendrocygna arcuata*	0	1	1	0	LC	-
Anatidae	Philippine Duck	*Anas luzonica* (a, b)	1	1	0	0	VU	VU
Phasianidae	Red Junglefowl	*Gallus gallus*	0	1	1	0	LC	-
Columbidae	Rock Pigeon	*Columba livia*	0	0	0	1	LC	-
Columbidae	Red Turtle Dove	*Streptopelia tranquebarica*	0	1	1	0	LC	-
Columbidae	Asian Emerald Dove	*Chalcophaps indica*	0	1	1	0	LC	-
Columbidae	Zebra Dove	*Geopelia striata*	1	0	0	1	LC	-
Columbidae	White-eared Brown-Dove	*Phapitreron leucotis* (a)	1	1	0	1	LC	-

Ardeidae	Cinnamon Bittern	*Ixobrychus cinnamomeus*	0	0	1	0	LC	-
Ardeidae	Grey Heron	*Ardea cinerea*	1	0	0	1	LC	-
Ardeidae	Purple Heron	*Ardea purpurea*	0	1	0	0	LC	-
Ardeidae	Great Egret	*Ardea alba*	1	1	1	0	LC	-
Ardeidae	Intermediate Egret	*Ardea intermedia*	1	1	1	1	LC	-
Ardeidae	Little Egret	*Egretta garzetta*	1	1	0	0	LC	-
Ardeidae	Cattle Egret	*Bubulcus ibis*	0	0	0	1	LC	-
Ardeidae	Javan Pond-Heron	*Ardeola speciosa*	1	0	0	1	LC	-
Ardeidae	Striated Heron	*Butorides striata*	0	1	0	0	LC	-
Ardeidae	Rufous Night-Heron	*Nycticorax caledonicus*	0	1	1	0	LC	-
Accipitridae	Philippine Serpent-Eagle	*Spilornis holospilus* (a, c; A-II)	0	1	1	0	LC	-
Accipitridae	Brahminy Kite	*Haliastur indus*	1	0	0	1	LC	-
Acrocephalidae	Clamorous Reed Warbler	*Acrocephalus stentoreus*	0	0	1	0	LC	-
Locustellidae	Tawny Grassbird	*Cincloramphus timoriensis*	1	1	1	0	LC	-
Locustellidae	Striated Grassbird	*Megalurus palustris*	0	1	0	1	LC	-
Hirundinidae	Barn Swallow	*Hirundo rustica*	1	1	0	1	LC	-
Pycnonotidae	Yellow-vented Bulbul	*Pycnonotus goiavier*	1	1	1	1	LC	-
Pycnonotidae	Philippine Bulbul	*Hypsipetes philippinus* (a)	0	0	1	0	LC	-
Zosteropidae	Lowland White-eye	*Zosterops meyeni* Bonaparte	0	0	0	1	LC	-
Cuculidae	Himalayan/Oriental Cuckoo	*Cuculus optatus*	1	0	0	0	LC	-
Podargidae	Philippine Frogmouth	*Batrachostomus septimus* (a)	1	1	1	0	LC	-
Caprimulgidae	Philippine Nightjar	*Caprimulgus manillensis* (a)	1	1	0	0	LC	-
Apodidae	Philippine Swiftlet	*Aerodramus mearnsi* (a)	1	1	0	0	LC	-
Rallidae	Barred Rail	*Gallirallus torquatus*	0	0	1	1	LC	-
Rallidae	Eurasian Moorhen	*Gallinula chloropus*	1	1	0	0	LC	-
Rallidae	Plain Bush-hen	*Amaurornis olivacea* (a)	0	1	0	0	LC	-
Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*	1	0	0	1	LC	-
Rallidae	Ruddy-breasted Crake	*Zapornia fusca*	0	0	1	0	LC	-

Bucerotidae	Rufous Hornbill	*Buceros hydrocorax semigaleatus* (a, c)	1	0	0	0	VU	EN
Alcedinidae	Collared Kingfisher	*Todiramphus chloris*	0	1	1	1	LC	-
Meropidae	Rufous-crowned Bee-eater	*Merops americanus*	0	0	0	1	LC	-
Meropidae	Blue-tailed Bee-eater	*Merops philippinus*	0	0	1	0	LC	-
Megalaimidae	Coppersmith Barbet	*Psilopogon haemacephalus*	1	1	0	0	LC	-
Psittaculidae	Blue-Naped Parrot	*Tanygnathus lucionensis* (a, b, c)	1	0	0	0	NT	CR
Psittaculidae	Guaiabero	*Bolbopsittacus lunulatus* (a)	1	0	1	0	LC	-
Psittaculidae	Philippine Hanging-Parrot	*Loriculus philippensis* (a, c)	1	0	1	0	LC	CR
Pittidae	Blue-breasted Pitta	*Erythropitta erythrogaster*	1	0	0	1	LC	-
Pittidae	Azure-breasted Pitta	*Pitta steerii* (a, b)	1	1	0	0	VU	VU
Sturnidae	Asian Glossy Starling	*Aplonis panayensis*	1	0	0	0	LC	-
Sturnidae	Coleto	*Sarcops calvus* (a)	0	1	0	0	LC	-
Muscicapidae	Philippine Magpie-Robin	*Copsychus mindanensis* (a)	1	0	0	0	LC	-
Dicaeidae	Red-keeled Flowerpecker	*Dicaeum australe* (a)	0	1	1	0	LC	-
Dicaeidae	Orange-bellied Flowerpecker	*Dicaeum trigonostigma*	1	1	0	0	LC	-
Coraciidae	Oriental Dollarbird	*Eurystomus orientalis*	1	0	0	0	LC	-

1 – present; 0 – absent

a – Endemic
b - KBA trigger species
c - CITES listed species

CR – Critically Endangered
EN – Endangered
VU - Vulnerable

NT – Near-threatened
LC – Least Concern

Discussion

The Philippines has relatively few peatlands compared to other countries but still plays a significant role in carbon storage and sequestration from the atmosphere (DENR-PAWB, 2005). Remarkably, avian species diversity of Southeast Asian peat swamp forests is high considering the harsh environmental condition and poor soil nutrients of the ecosystem (Schrevel, 2008). For instance, Berbak National Park in Sumatra Island, Indonesia, Maludam National Park, and south-east Pahang peat swamp forest, and several peat swamp forests in Sarawak Malaysia documented 224, 192, and 227 bird species, respectively (Schrevel, 2008; Mohd Azmi et al., 2009; Ramji et al., 2016).

Secondary data from ADB (2000) recorded 62 avian species in LSBP, wherein the highest concentration of avifauna was documented in peat swamp forest. Surprisingly in the current study, the LSBP is still able to support a significant number of bird species (n= 67) (Table 2) despite the short duration of the sampling effort.

Survival of avian species is crucial in fragmented forest patches of peat swamp forest in south-western Sarawak since they only recorded fewer bird species (Ramji et al., 2016). Thus, the persistence of avifauna is dependent on the landscape features, overall size, area, flora, and vegetation structure, as evidenced by the occurrence of forest-interior species that can regularly survive the quality of the environment (Sodhi et al., 2008).

In LSBP, it was observed among all sites that Brgy. Tabangohay, where the majority of the wetland forest thrives, was the thriving hub and nesting site of some threatened species of birds like the Southern Rufous Hornbill (*B. hydrocorax*), the rare and endangered Blue-naped Parrot (*T. lucionensis*), as well as a nesting site for Brahminy Kite Eagle (*Haliastur indus*). This is mainly due to the high distribution of Toog tree (*Petersianthus quadrialatus*) and Dao (*Dracontomelon dao*) along the forest edge.

We also discovered that Brgy. Langit, typically along the peat bog covered by natural vegetation communities of sedges, grasses, and hydrophytes, is one of the nesting sites of the threatened species of Philippine Duck (*A. luzonica*) while Brgy. Magsaysay, specifically with patches of wetland forest, is an abode to some notable species such as the Philippine Frogmouth (*Batrachostomus septimus*) and the Philippine Nightjar (*Caprimulgus manillensis*). Migratory bird species were also documented in almost all study sites despite having disturbed ecosystems brought by mono-crop agriculture and human encroachment.

As reported by an ADB study (2000), Wandering Whistling Duck (*Dendrocygna arcuata*) was the most significant number of individuals documented in sedge-grassland and agroecosystem with portions of peat bog areas and patches of wetland forest habitats sighted along the marshy and swampy area of these ecotypes. However, in our study, we mainly observed the Philippine Duck (*A. luzonica*) and rarely observed the Wandering Whistling Duck (*D. arcuata*). These species are integral components in these ecotypes as it maintains the ecological balance in their associated ecosystem and feeds on aquatic plants, mollusks, worms, frogs, fish, reptiles, and insects (Carboneras & Kirwan, 2020). Other prominent bird taxa recorded belong to Cuculidae (cuckoos and coucals) and Rallidae (rails moorhens). It is important to note that these taxa still exist in the peatland. In an agroecosystem-sedge-grassland habitat with patches of wetland forest and lumbia within the ricefields, the important avian taxon was that of the family Columbidae (pigeons and doves) where this taxon can be seen abundantly in the peatland during our sampling as well as in peat bog area in Langit and wetland forests-terminalia stands. It is also noteworthy that peat swamp forests heavily logged can still accommodate the high richness of the avian community. The high similarity in terms of abundance of avifauna detected in secondary forests and shrub swamps implies that the Berbak National Park still provides a significantly good environment for the existence of various species of birds, especially those species which have high conservation value and thrive in the primary forest zones (Darras et al., 2018). The same was observed in LSBP, wherein many bird species were documented despite its land-use conversion. Those species with high conservation value still exist in the remaining peat swamp forest, precisely in Brgy. Tabangohay.

In Ramji et al. (2016) study, families with the most significant number of species composed of primarily forest-dependent species such as Timaliidae-babblers, Cuculidae- cuckoos Picidae-woodpeckers, Muscicapidae- flycatchers, Pycnonotidae-bulbuls and Nectariniidae –sunbirds and spiderhunters. In addition, they also documented 31 migratory birds, including most waterbirds (egrets, herons, bitterns, waders, plovers), wagtails, barn swallow *Hirundo rustica*, and common kingfisher *Alcedo atthis*. The high occurrence of waterbirds and shorebirds species of the families Ardeidae, Scolopacidae, and Charadriidae indicate that peat swamp forest has been utilized as a stable and alternative refuge for thousands of migrating bird populations (Minayeva, 2008).

The last remaining untouched peatland provides a haven for migratory bird species that profoundly rely on this wetland ecosystem. These are almost automatically designated as buffer zones in the management planning regimes. Our study result shows that most of the threatened species are found within the circumference of the wetland that is still intact; this is where the highest species diversity of key species was found. For instance, the endemic and threatened bird species such as Rufous Hornbill (*B. hydrocorax*) and Blue-naped Parrot (*T. lucionensis*) we found in Brgy. Tabangohay is being threatened by wildlife poaching and road widening.

Wildlife hunting is being practiced even by younger children in some barangays adjacent to the wetland. Because many communities in these areas are dependent on peatland forest, human encroachment is rampant across the wetland, creating tenurial conflict that compromises the last remaining stronghold of the forest. Regrettably, this kind of ecological malpractice is being embraced by the new generations, reflecting an insufficient knowledge of the importance of conservation. To eradicate wrong beliefs and deceptive traditions, information, education, and communication (IEC) campaigns in local communities should be done regularly. Conventional use of ecosystem services such as eco-tourism and bird watching has a vast potential source of alternative livelihood for the communities to lessen these wrong-doings.

During the study, we observed pre-existing threats such as mono-crop agriculture, exotic tree plantation, and slash and burn activity, indicating moderate vulnerability to peatland forest ecosystem degradation. The emerging threats of anthropogenic pressures such as road widening, quarrying, reclamation, and land conversion suggest a high susceptibility to deposition of the wetland. These vulnerabilities, however, can be reduced with dense vegetation and restoration initiatives of the previously abandoned agricultural land. Creating permanent agricultural sites or shifting plots outside the buffer zones can also be considered. Native trees rather than exotic ones should restore agricultural areas that are no longer tenable. Invasive and exotic tree plantations such as Big-leaf Mahoganies (*Swietenia macrophylla*), Magium tree (*Acacia mangium*), Ipil-ipil (*Leucaena leucocephala*), and Neem Tree (*Azadirachta indica*) that were observed on almost all of the study sites should also be discouraged. The innate high infiltration capacity of peatland contributes to a more extended time of peak flow, further lowering the risk of drying out during the dry season. Thus, removing these invasive tree species and replacing them with native ones can significantly help the wetland recover.

Conclusion

The LSBP exhibits a high species richness of the avian community despite the short sampling effort. Thus, it should not be overlooked in terms of their ecological role as significant habitat for migratory waterbirds, forest-dependent bird species, threatened, endangered, critically endangered species, and endemics. The LSBP has the potential to be a critical habitat or Ramsar site since various species of threatened and migratory bird species were observed inhabiting the peatland. The strict protection zone should be established first, especially on the last remaining untouched areas of the wetland, while enhancing the vegetation of those affected ones. An in-depth scientific study of the Leyte Sab-a Basin Peatland is recommended including seasonal patterns of the avian community since even a small habitat cannot cover all taxonomic groups in just a short period. It is also unlikely to make a fair assessment of the total bird richness and diversity for the simple reason that not all organisms will be found to be present together in several surveys. Detailed and comprehensive assessments must be done to know more about the biodiversity of the avifauna community of the peatland.

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Table S1. The cumulative contribution of bird species towards dissimilarity (Jaccard) between sites based on SIMPER analysis.

	Average dissimilarity	Alangalang	Sta Fe	Cumulative Contribution
Average dissimilarity = 55.4%				
Tringa stagnatilis	0.012	1	0	0.032
Lalage nigra	0.012	0	1	0.065
Oriolus chinensis	0.012	1	0	0.097
Dendrocygna arcuata	0.012	0	1	0.129
Gallus gallus	0.012	0	1	0.161
Streptopelia tranquebarica	0.012	0	1	0.194
Chalcophaps indica	0.012	0	1	0.226
Geopelia striata	0.012	1	0	0.258
Ardea cinerea	0.012	1	0	0.290
Ardea purpurea	0.012	0	1	0.323
Ardeola speciosa	0.012	1	0	0.355
Butorides striata	0.012	0	1	0.387
Nycticorax caledonicus	0.012	0	1	0.419
Spilornis holospilus	0.012	0	1	0.452
Haliastur indus	0.012	1	0	0.484
Cisticola exilis	0.012	0	1	0.516
Megalurus palustris	0.012	0	1	0.548
Cuculus optatus	0.012	1	0	0.581
Amaurornis olivacea	0.012	0	1	0.613
Amaurornis phoenicurus	0.012	1	0	0.645
Buceros hydrocorax	0.012	1	0	0.677
Todiramphus chloris	0.012	0	1	0.710
Tanygnathus lucionensis	0.012	1	0	0.742
Bolbopsittacus lunulatus	0.012	1	0	0.774
Loriculus philippensis	0.012	1	0	0.806
Erythropitta erythrogaster	0.012	1	0	0.839
Aplonis panayensis	0.012	1	0	0.871
Sarcops calvus	0.012	0	1	0.903
Copsychus mindanensis	0.012	1	0	0.935
Dicaeum australe	0.012	0	1	0.968
Eurystomus orientalis	0.012	1	0	1.000
	Average dissimilarity	Alangalang	San Miguel	Cumulative Contribution
Average dissimilarity = 70.2%				
Charadrius mongolus	0.014	1	0	0.025
Lanius schach	0.014	1	0	0.050
Orthotomus frontalis	0.014	0	1	0.075
Dendrocygna arcuata	0.014	0	1	0.100
Anas luzonica	0.014	1	0	0.125
Gallus gallus	0.014	0	1	0.150

Streptopelia tranquebarica	0.014	0	1	0.175
Chalcophaps indica	0.014	0	1	0.200
Geopelia striata	0.014	1	0	0.225
Phapitreron leucotis	0.014	1	0	0.250
Ixobrychus cinnamomeus	0.014	0	1	0.275
Ardea cinerea	0.014	1	0	0.300
Egretta garzetta	0.014	1	0	0.325
Ardeola speciosa	0.014	1	0	0.350
Nycticorax caledonicus	0.014	0	1	0.375
Spilornis holospilus	0.014	0	1	0.400
Haliastur indus	0.014	1	0	0.425
Cisticola exilis	0.014	0	1	0.450
Acrocephalus stentoreus	0.014	0	1	0.475
Hirundo rustica	0.014	1	0	0.500
Hypsipetes philippinus	0.014	0	1	0.525
Cuculus optatus	0.014	1	0	0.550
Caprimulgus manillensis	0.014	1	0	0.575
Aerodramus mearnsi	0.014	1	0	0.600
Gallirallus torquatus	0.014	0	1	0.625
Gallinula chloropus	0.014	1	0	0.650
Amaurornis phoenicurus	0.014	1	0	0.675
Zapornia fusca	0.014	0	1	0.700
Buceros hydrocorax	0.014	1	0	0.725
Todiramphus chloris	0.014	0	1	0.750
Merops philippinus	0.014	0	1	0.775
Psilopogon haemacephalus	0.014	1	0	0.800
Tanygnathus lucionensis	0.014	1	0	0.825
Erythropitta erythrogaster	0.014	1	0	0.850
Pitta steerii	0.014	1	0	0.875
Aplonis panayensis	0.014	1	0	0.900
Copsychus mindanensis	0.014	1	0	0.925
Dicaeum australe	0.014	0	1	0.950
Dicaeum trigonostigma	0.014	1	0	0.975
Eurystomus orientalis	0.014	1	0	1.000
	Average dissimilarity	Alangalang	Tacloban	Cumulative Contribution
Average dissimilarity = 66%				
Tringa stagnatilis	0.015	1	0	0.030
Gerygone sulphurea	0.015	1	0	0.061
Lalage nigra	0.015	0	1	0.091
Oriolus chinensis	0.015	1	0	0.121
Lanius cristatus	0.015	1	0	0.152
Corvus macrorhynchos	0.015	1	0	0.182
Orthotomus frontalis	0.015	0	1	0.212
Anas luzonica	0.015	1	0	0.242

Columba livia	0.015	0	1	0.273
Ardea alba	0.015	1	0	0.303
Egretta garzetta	0.015	1	0	0.333
Bubulcus ibis	0.015	0	1	0.364
Cincloramphus timoriensis	0.015	1	0	0.394
Megalurus palustris	0.015	0	1	0.424
Zosterops meyeni	0.015	0	1	0.455
Cuculus optatus	0.015	1	0	0.485
Batrachostomus septimus	0.015	1	0	0.515
Caprimulgus manillensis	0.015	1	0	0.545
Aerodramus mearnsi	0.015	1	0	0.576
Gallirallus torquatus	0.015	0	1	0.606
Gallinula chloropus	0.015	1	0	0.636
Buceros hydrocorax	0.015	1	0	0.667
Todiramphus chloris	0.015	0	1	0.697
Merops americanus	0.015	0	1	0.727
Psilopogon haemacephalus	0.015	1	0	0.758
Tanygnathus lucionensis	0.015	1	0	0.788
Bolbopsittacus lunulatus	0.015	1	0	0.818
Loriculus philippensis	0.015	1	0	0.848
Pitta steerii	0.015	1	0	0.879
Aplonis panayensis	0.015	1	0	0.909
Copsychus mindanensis	0.015	1	0	0.939
Dicaeum trigonostigma	0.015	1	0	0.970
Eurystomus orientalis	0.015	1	0	1.000
	Average dissimilarity	Sta Fe	San Miguel	Cumulative Contribution
Average dissimilarity = 56.9%				
Charadrius mongolus	0.014	1	0	0.034
Tringa stagnatilis	0.014	0	1	0.069
Lalage nigra	0.014	1	0	0.103
Oriolus chinensis	0.014	0	1	0.138
Lanius schach	0.014	1	0	0.172
Orthotomus frontalis	0.014	0	1	0.207
Anas luzonica	0.014	1	0	0.241
Phapitreron leucotis	0.014	1	0	0.276
Ixobrychus cinnamomeus	0.014	0	1	0.310
Ardea purpurea	0.014	1	0	0.345
Egretta garzetta	0.014	1	0	0.379
Butorides striata	0.014	1	0	0.414
Acrocephalus stentoreus	0.014	0	1	0.448
Megalurus palustris	0.014	1	0	0.483
Hirundo rustica	0.014	1	0	0.517
Hypsipetes philippinus	0.014	0	1	0.552
Caprimulgus manillensis	0.014	1	0	0.586

Aerodramus mearnsi	0.014	1	0	0.621
Gallirallus torquatus	0.014	0	1	0.655
Gallinula chloropus	0.014	1	0	0.690
Amaurornis olivacea	0.014	1	0	0.724
Zapornia fusca	0.014	0	1	0.759
Merops philippinus	0.014	0	1	0.793
Psilopogon haemacephalus	0.014	1	0	0.828
Bolbopsittacus lunulatus	0.014	0	1	0.862
Loriculus philippensis	0.014	0	1	0.897
Pitta steerii	0.014	1	0	0.931
Sarcops calvus	0.014	1	0	0.966
Dicaeum trigonostigma	0.014	1	0	1.000
	Average dissimilarity	Sta Fe	Tacloban	Cumulative Contribution
Average dissimilarity = 73.1%				
Gerygone sulphurea	0.015	1	0	0.026
Lanius cristatus	0.015	1	0	0.053
Corvus macrorhynchos	0.015	1	0	0.079
Orthotomus frontalis	0.015	0	1	0.105
Dendrocygna arcuata	0.015	1	0	0.132
Anas luzonica	0.015	1	0	0.158
Gallus gallus	0.015	1	0	0.184
Columba livia	0.015	0	1	0.211
Streptopelia tranquebarica	0.015	1	0	0.237
Chalcophaps indica	0.015	1	0	0.263
Geopelia striata	0.015	0	1	0.289
Ardea cinerea	0.015	0	1	0.316
Ardea purpurea	0.015	1	0	0.342
Ardea alba	0.015	1	0	0.368
Egretta garzetta	0.015	1	0	0.395
Bubulcus ibis	0.015	0	1	0.421
Ardeola speciosa	0.015	0	1	0.447
Butorides striata	0.015	1	0	0.474
Nycticorax caledonicus	0.015	1	0	0.500
Spilornis holospilus	0.015	1	0	0.526
Haliastur indus	0.015	0	1	0.553
Cisticola exilis	0.015	1	0	0.579
Cincloramphus timoriensis	0.015	1	0	0.605
Zosterops meyeni	0.015	0	1	0.632
Batrachostomus septimus	0.015	1	0	0.658
Caprimulgus manillensis	0.015	1	0	0.684
Aerodramus mearnsi	0.015	1	0	0.711
Gallirallus torquatus	0.015	0	1	0.737
Gallinula chloropus	0.015	1	0	0.763
Amaurornis olivacea	0.015	1	0	0.789

Amaurornis phoenicurus	0.015	0	1	0.816
Merops americanus	0.015	0	1	0.842
Psilopogon haemacephalus	0.015	1	0	0.868
Erythropitta erythrogaster	0.015	0	1	0.895
Pitta steerii	0.015	1	0	0.921
Sarcops calvus	0.015	1	0	0.947
Dicaeum australe	0.015	1	0	0.974
Dicaeum trigonostigma	0.015	1	0	1.000
	Average dissimilarity	San Miguel	Tacloban	Cumulative Contribution
Average dissimilarity = 79.6%				
Charadrius mongolus	0.017	0	1	0.026
Tringa stagnatilis	0.017	1	0	0.051
Gerygone sulphurea	0.017	1	0	0.077
Lalage nigra	0.017	0	1	0.103
Oriolus chinensis	0.017	1	0	0.128
Lanius cristatus	0.017	1	0	0.154
Lanius schach	0.017	0	1	0.179
Corvus macrorhynchos	0.017	1	0	0.205
Dendrocygna arcuata	0.017	1	0	0.231
Gallus gallus	0.017	1	0	0.256
Columba livia	0.017	0	1	0.282
Streptopelia tranquebarica	0.017	1	0	0.308
Chalcophaps indica	0.017	1	0	0.333
Geopelia striata	0.017	0	1	0.359
Phapitreron leucotis	0.017	0	1	0.385
Ixobrychus cinnamomeus	0.017	1	0	0.410
Ardea cinerea	0.017	0	1	0.436
Ardea alba	0.017	1	0	0.462
Bubulcus ibis	0.017	0	1	0.487
Ardeola speciosa	0.017	0	1	0.513
Nycticorax caledonicus	0.017	1	0	0.538
Spilornis holospilus	0.017	1	0	0.564
Haliastur indus	0.017	0	1	0.590
Cisticola exilis	0.017	1	0	0.615
Acrocephalus stentoreus	0.017	1	0	0.641
Cincloramphus timoriensis	0.017	1	0	0.667
Megalurus palustris	0.017	0	1	0.692
Hirundo rustica	0.017	0	1	0.718
Hypsipetes philippinus	0.017	1	0	0.744
Zosterops meyeni	0.017	0	1	0.769
Batrachostomus septimus	0.017	1	0	0.795
Amaurornis phoenicurus	0.017	0	1	0.821
Zapornia fusca	0.017	1	0	0.846
Merops americanus	0.017	0	1	0.872

Merops philippinus	0.017	1	0	0.897
Bolbopsittacus lunulatus	0.017	1	0	0.923
Loriculus philippensis	0.017	1	0	0.949
Erythropitta erythrogaster	0.017	0	1	0.974
Dicaeum australe	0.017	1	0	1.000