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Vertebrate faunal diversity in Mt. Calavite Wildlife Sanctuary, Occidental Mindoro, Philippines: An assessment using the Biodiversity Assessment and Monitoring System (BAMS)

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Abstract

Rich biodiversity is one of the Philippines' greatest assets of which populations of flora and fauna continuously face massive threats due to anthropogenic interventions. This study in Mt. Calavite Wildlife Sanctuary (MCWS) is one of the pioneering research projects on vertebrate fauna in a permanent biodiversity monitoring plot that followed a nationally accepted system of biodiversity assessment and monitoring for species and habitat conservation. The study established a 2-ha Permanent Biodiversity Monitoring Area (PBMA) following the procedures in the Biodiversity Assessment and Monitoring System crafted by the Department of Environment and Natural Resources – Biodiversity Management Bureau. Results showed that MCWS was home to different kinds of vertebrate fauna including 23 bird species from 17 families, 7 mammalian species from 6 families, and 8 herpetofauna species from 7 families. The habitat association assessment revealed

that the majority of species were forest-dependent and some were associated with grassland, agricultural areas, and forest streams. The computed diversity values in MCWS were generally higher than in other areas in the Philippines. Lastly, a high percentage of ecologically important species were recorded including the native, endemic, and threatened species. The study revealed the presence of essential species that shall be prioritized for conservation. The product of this study can act as baseline information for the continuous monitoring of the area and can further be used in crafting more appropriate and comprehensive conservation and management plans for the area.
Keywords: Biodiversity, birds, herpetofauna, mammals, Mindoro Endemics, Philippine endemics, reptiles, threatened fauna

Introduction

The Philippine archipelago is considered one of the megadiverse countries worldwide (von Rintelen et al., 2017). The biodiversity resources in the Philippines are primarily confined to some 240 protected areas occupying 5.45 million hectares in the country (Biodiversity Management Bureau, 2015). Despite establishing and declaring these protected areas, biodiversity continues to decline (Zapanta et al., 2019; Singh, 2020). Thus, the generation of baseline information in protected areas is vital in the planning and development of effective conservation and protection schemes.

In 2001, the Philippines' Department of Environment and Natural Resources (DENR) with the Nordic Agency for Development and Ecology (NORDECO) devised a Biodiversity Monitoring System (BMS). This system identifies the extensiveness of different ecosystem types and sub-types, the status of threatened species, the impact of management intervention on the ecosystem, and the benefits of sustainable natural resource use to local communities (NORDECO and DENR, 2001). The BMS was further enhanced by implementing Biodiversity Assessment and Monitoring System (BAMS) as stipulated in DENR Memorandum Order No. 1991-10. BAMS provides guidelines for conducting biodiversity inventory in protected areas (Biodiversity Management Bureau and Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH, 2017). It also includes the establishment of permanent monitoring plots for an in-depth, long-term ecological monitoring system. It utilizes Geographical Information Systems (GIS) to monitor biodiversity resources in protected areas. Assessment and monitoring schemes like this are ideal as it promotes regular and long-term assessment and monitoring of the biodiversity resources.

The regular assessment and long-term monitoring of biodiversity and ecology are essential in understanding the bioecological changes in protected areas (Pereira et al., 2017; Mohammadizadeh et al. 2022). The organization, storage, and retrieval of relevant biodiversity data into a systematic documentation approach are linked to sustainable management (Lee et al., 2005). It can further provide necessary action plans toward issues confronting the state of biodiversity resources in protected areas, such as Mt. Calavite Wildlife Sanctuary on Mindoro Island.

Mindoro is a 10,244 km^2 island possessing exemplary records of rich biodiversity. It covers ten important sites (Mount Malasimbo, Mount Halcon, Bulalacao-Mansalay, Abra de Ilog, Mount Hinunduang, Mount Siburan, and Ilin Island) prioritized by the Mindoro Biodiversity Conservation Foundation, Inc. of which three are protected areas (Mt. Calavite Wildlife Sanctuary, Apo Reef Natural Park, and Lake Najuan National Park) (Gatumbato, 2009). Tamaraw or *Bubalus mindorensis* Heude is one of its most important species, holding a record of being endemic only on the island (Matsubayashi et al., 2010). It is critically endangered as listed in the IUCN Red List of Threatened Species (IUCN, 2022).

Mt. Calavite was a game refuge and a bird sanctuary declared by the country's Executive Order No. 9 on January 28, 1920, and was renamed Mt. Calavite Wildlife Sanctuary by Proclamation No. 292 s. 2000 (BirdLife International, 2020). A recent biodiversity survey conducted in 2014 by the Mindoro Biodiversity Conservation Foundation, Inc. (MBCFI) in four localities within the mountain reported a total of 134 species of terrestrial vertebrates, comprising 109 species of birds, 16 mammals, and 9 species of frogs and reptiles (Mindoro Biodiversity Conservation Foundation, Inc., 2014). These figures also include several species of Mindoro endemic and globally threatened vertebrates.

Thus, this present study will help in updating the current status of the vertebrate fauna in the area. Moreover, this will include the establishment of permanent biodiversity plots for the continuous monitoring of the wildlife populations in the protected area. The results of this study are also crucial for the development of conservation and management plans.

Material and methods

Study Site

The chosen study site in Mt. Calavite Wildlife Sanctuary was locally known as Sitio Caraga (Fig. 1). The area is located at the northwestern tip of Mindoro Island (13°25'23.90" N and 120°21'2.70" E) with an elevation of 122 meters above sea level. It belongs to the country's Climate Type I classification which is characterized to have two pronounced seasons, dry from November to April and wet during the rest of the year, with a maximum rain period observed from June to September (Mindoro Biodiversity Conservation Foundation, Inc., 2014). Moreover, the average monthly temperature in the area was estimated at a minimum of 23.3°C and a maximum of 31.3°C.

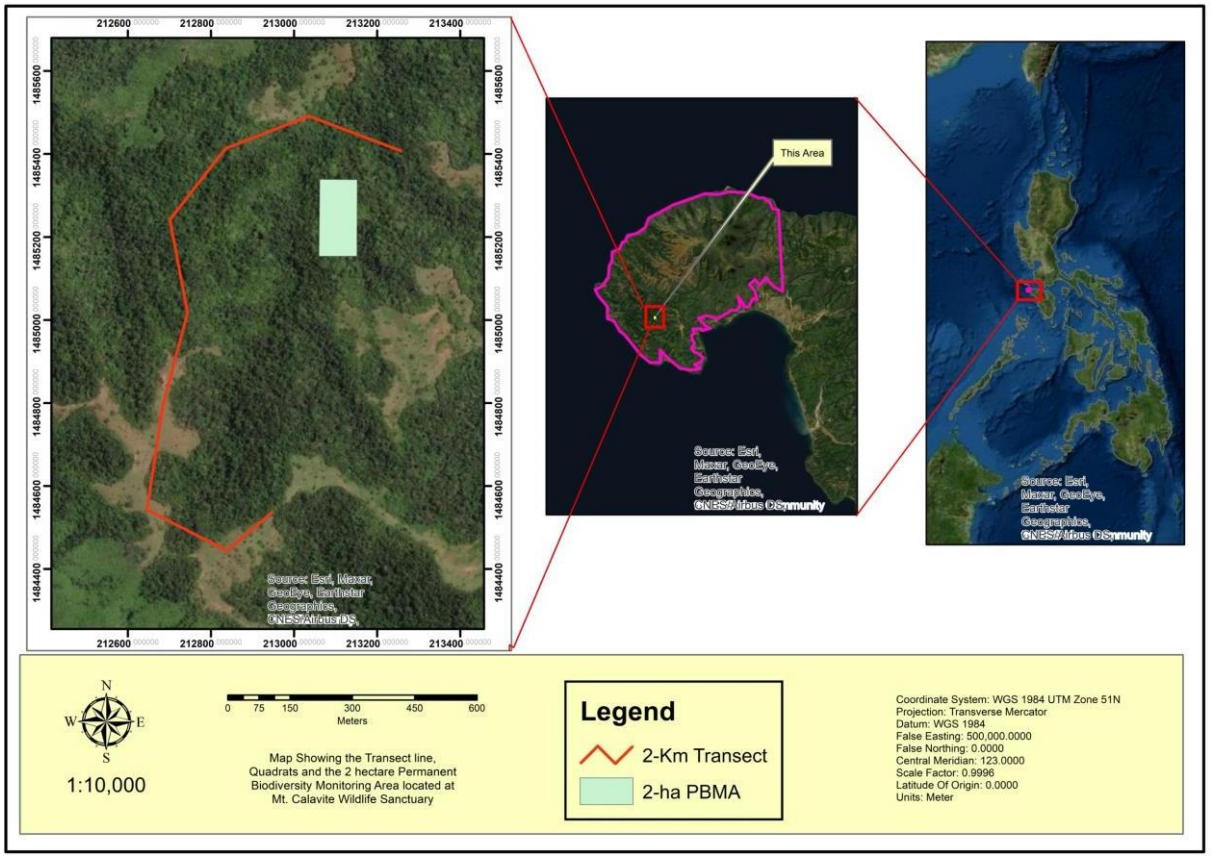

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Figure 1. Location map of the study site in the protected area of Mt. Calavite Wildlife Sanctuary showing Sitio Caraga where the data collection was done (see red rectangle)

Establishment of 2-ha Permanent Biodiversity Monitoring Area (PBMA)

The study followed the Biodiversity Assessment and Monitoring System (BAMS) of the Department of Environment and Natural Resources – Biodiversity and Management Bureau. Thus, the 2-ha PBMA was established based on a pre-survey of a 2-km transect. This was done to gather information about the types of ecosystems in the area and the associated species therewith. The rule in the system is to ensure the representativeness of the habitats (i.e., ecosystem types) in the 2-ha PBMA.

The 2-ha PBMA was selected in August 2018 based on the results of the rapid assessment of the 2-km transect. In the 2-km transect, the ecosystems found were grassland, shrubland, and open/broad leaf forests. Hence, the chosen area for the permanent plot was a middle-aged secondary forest with patches of grassland and shrubland. In establishing the PBMA, *Syzygium nitidum* Benth. was used as tie points for the four corners (Fig. 2). All the tie points were marked with yellow paint. The dimensions of the plot were laid in a due south direction with a horizontal distance of 200 meters. The other dimension was established due west measuring 100 meters in horizontal distance.

Afterward, the plot was divided into fifty 20by20-m plots for a more convenient location referencing.

Figure 2. Photographs of the boundaries and GPS records of the 2-hectare Permanent Biodiversity Monitoring Area at Mt. Calavite Wildlife Sanctuary. The first row: Plotted points of 2-ha perimeter, Corner 1 (C1), second row: Corner 2 (C2), Corner 3 (C3).

Faunal Survey inside the 2-ha PBMA

Five methods were used for faunal recording and assessment such as point counts, mist-netting, live trapping, heterofaunal sampling, and opportunistic sampling.

Point counts were employed for localized and relatively small areal coverage, to document bird diversity within its confines. A total of five points were used with a distance between two points measured at 80-100 meters. Fifteen to 20 minutes were spent at each point, noting the species and abundance per bird encounter. Point counts were done in the early morning usually at 0530h. Bird point counts were done only once during the four-day survey.

Mist netting was used to capture birds and bats. A total of twelve mist nets comprising four separate stations were set within the PBMA. This method was used in capturing birds and documenting bat diversity. As such, mist nets were placed along the existing trail, at ridge-top, and a forest clearing. Two net stations were set near the ground, whereas the other two were set ca. 7-10 meters above the ground. Captured birds and bats were identified as species and the number of captures was noted. Additional information gathered also included some morphometries (such as weight, total length, wing cord, forearm), reproductive condition, and age class (e.g. whether juvenile/immature or adult).

Cage traps baited with fried coconut strips coated with peanut butter were used in recording small non-flying mammals (i.e., shrews and rodents). At least 30 traps were distributed across the 2-hectare plot in places where there are signs of small mammal traffic (i.e., runways usuallyunderneath trees, logs, and boulders).

For the herpetofauna sampling, the same points used in the bird survey were also utilized in searching for frogs and reptiles. Herpetofaunal searches were done during 1300h-1500h (day time) and 1900h-2100h (night time), but encounters during the rest of the day were also noted.

Species found in the area were identified and photo documented. The identification was done based on the morphological characteristics of the individuals and with the help of published references. For the bird species, the book *A Guide to the Birds of the Philippines* by Kennedy et al. (2000) was used. Meanwhile, the book *Key to the bats of the Philippine Islands* (Ingle and Heaney, 1992) was used in identifying bats with the help of obtained body measurements.

Data Analysis

For the data analysis, species richness, density, and diversity indices were computed. Species richness refers to the total number of species documented, captured, and recorded per taxonomic group (each for birds, mammals, reptiles, and amphibians). Diversity indices such as Shannon diversity (Shannon, 1948) and Simpson Evenness (Simpson, 1949) were computed using the PAST vers. 4.06 (Hammer et al., 2001).

Notes on the ecological importance and threat were also assessed. It includes habitat association, conservation status, and endemism. Habitat association determines which habitat type/s a certain species belongs to. For a given set of species composition or community, special attention will be given to the proportion of species richness associated with what type of habitat (e.g. forest-dependents, grassland dependents, disturbed areas associated). Moreover, the conservation status of each recorded species was assessed of its threatened status based on the latest IUCN Red List of Threatened Species (IUCN, 2022) on the international scale. For the national conservation status,

the DENR Administrative Order 2019-19 (DAO 2019-09) or the Updated National List of Threatened Philippine Fauna and their Categories was used (DENR, 2019). Lastly, the endemism of each species was assessed whether it is Philippine endemic, Mindoro endemic, or non-endemic.

Results

Bird Diversity and Composition

A total of 23 bird species from 17 families were recorded in the area (Table 1). The most species-rich family was Psittacidae with 3 species. The rest of the families had one to two species. On the other hand, the most dominant family was Pycnonotidae with 17 individuals from its lone species in the site, *Hypsipetes philippinus* (J. R. Forster, 1795) locally known as the Philippine Bulbul making it the most dominant species as well. The other families had individuals ranging from one to 13. All the species recorded were obligate forest lowland dwellers, or most often associated with forest vegetation. In terms of diversity indices, the computed Shannon diversity (H') was 2.78, while the Simpson Evenness was 0.92.

Table 1. Taxonomic list of avian species found in the 2-ha PBMA with corresponding endemism, conservation status, and abundance

No.	Species	Common Name	Endemism	IUCN Threatened Status	Philippine Threatened Status	Abundance
Family PHASIANIDAE						
1	*Gallus gallus* (Linnaeus, 1758)	Red Jungle Fowl	NE	LC	-	1
Family COLUMBIDAE						
2	*Phapitreron leucotis* (Temminck, 1823)	White-eared Brown-Dove	PE	LC	-	5
3	*Ramphiculus occipitalis* (del Hoyo and Collar 2014)	Yellow-breasted Fruit-Dove	PE	LC	-	1
Family ACCIPITRIDAE						
4	*Accipiter virgatus* (Temminck, 1822)	Besra	NE	LC	-	1
Family BUCEROTIDAE						
5	*Penelopides mindorensis* Steere, 1890	Mindoro Hornbill	ME	EN	EN	7
Family ALCEDINIDAE						
6	*Alcedo cyanopectus* (Lafresnaye, 1840)	Indigo-banded Kingfisher	PE	LC	-	1
7	*Ceyx erithaca* (Linnaeus, 1758)	Oriental Dwarf Kingfisher	NE	LC	-	1
Family PICIDAE						
8	*Dryocopus javensis* (Horsfield, 1821)	White-bellied Woodpecker	NE	LC	-	2
Family PSITTACIDAE						
9	*Tanygnathus lucionensis* (Linnaeus, 1766)	Blue-naped Parrot	PE	NT	CR	8
10	*Prioniturus discurus* (Vieillot, 1822)	Blue-crowned Racquet-tail	PE	LC	OTS	2

11	*Loriculus philippensis mindorensis* Steere, 1890	Colasisi/Philippine Hanging Parrot	PE	VU	CR	3
Family PITTIDAE						
12	*Erythropitta erythrogaster* (Temminck, 1823)	Philippine Pitta	PE	LC	-	1
Family PACHYCEPHALIDAE						
13	*Pachycephala albiventris* (Ogilvie-Grant, 1894)	Green-backed Whistler	PE	LC	-	4
Family CAMPEPHAGIDAE						
14	*Coracina striata* (Boddaert, 1783)	Bar-bellied Cuckoo-Shrike	PE	LC	-	6
Family DICRURIDAE						
15	*Dicrurus balicassius* (Linnaeus, 1766)	Balicassiao	PE	LC	-	9
Family MONARCHIDAE						
16	*Hypothymis azurea* (Boddaert, 1783)	Black-naped Blue Monarch	NE	LC	-	2
17	*Corvus macrorhynchos* Wagler, 1827	Large-billed Crow	NE	LC	-	3
Family PYCNONOTIDAE						
18	*Hypsipetes philippinus* (J. R. Forster, 1795)	Philippine Bulbul	PE	LC	-	17
Family ZOSTEROPIDAE						
19	*Zosterops nigrorum* Tweeddale, 1878	Yellowish White-eye	PE	LC	-	8
Family STURNIDAE						
20	*Sarcops calvus* (Linnaeus, 1766)	Coleteo	PE	LC	-	4
Family DICAEIDAE						
21	*Dicaeum bicolor* (Bourns & Worcester, 1894)	Bicolored Flowerpecker	PE	LC	-	2
22	*Dicaeum retrocinctum* Gould, 1872	Scarlet-collared Flowerpecker	ME	VU	VU	3
Family NECTARINIIDAE						
23	*Aethopyga shelleyi* Sharpe, 1876	Lovely Sunbird	PE	LC	-	1
Total Number of Individuals						**92**
Total Number of Species						**23**

Note: Endemism (PE – Philippine Endemic, ME – Mindoro Endemic, NE – Non-endemic); IUCN Status (CR – Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened, LC – Least Concern)

Among the 23 species recorded, 73.91% (17 species) were either Philippine endemic (15 species) or restricted to the island of Mindoro (2 species). In addition, 82 out of 92 individuals were endemic (89.13%). Regarding the conservation status, three species were internationally threatened based on the IUCN Red List of Threatened Species (IUCN, 2022). These species were the endangered *Penelopides mindorensis* Steere, 1890, and the vulnerable *Loriculus philippensis mindorensis* Steere, 1890 and *Dicaeum retrocinctum* Gould, 1872. In terms of the nationally threatened species based on the DAO 2019-09 in the Philippines, five species were included. Among these were the

two critically endangered species from the family Psittacidae, *Tanygnathus lucionensis* (Linnaeus, 1766) and *Loriculus philippensis mindorensis* Steere, 1890.

Mammalian Diversity and Composition

Twenty-one individuals from seven mammalian species and six families were recorded during the survey in the permanent plot. These species were comprised of two fruit bats, a rodent, a macaque, a palm civet, a warty pig, and a cervid deer (Table 2). The most dominant family was Pteropodidae with two species and 11 individuals. Among the species, only four were directly observed and trapped. The other three species namely, *Sus oliveri* Groves, 1997, *Rusa marianna* (Desmarest, 1822), and *Viverra tangalunga* Gray, 1832. The record of *S. oliveri* was based on the diggings and wallows of which some were fresh or newly made. For the record of *R. marianna*, footprints were observed in the PBMA presumably from one individual. The *V. tangalunga* was based on a fecal material in a dry creek inside the PBMA. In terms of habitat, most of the species were associated either with forest and agricultural or grassland areas, but most commonly in secondary forests. Regarding diversity indices, the computed values for H' and Simpson Evenness were 1.68 and 0.80, respectively.

Table 2. Taxonomic list of mammalian species found in the 2-ha PBMA with corresponding residency status, population and threat statuses, observation notes, and abundance

No.	Species	Common Name	Residency status	Population and Threat status	Observation Notes	Abundance
Family PTEROPODIDAE						
1	*Cynopterus luzoniensis* (Peters, 1861)	Common short-nosed fruit bat	Native, non-endemic	Common, Least Concern	Netted in grassland, forest edge, and forest interior	7
2	*Ptenochirus jagorii* (Peters, 1861)	Musky fruit bat	Native**; Philippine Endemic**	Abundant in all habitat types especially at low elevations, Least Concern		4
Family MURIDAE						
3	*Rattus tanezumi* (Temminck, 1845)	Oriental house rat	Non-native, pest	Abundant in agricultural areas, and may encroach in adjacent forest, Least Concern	Trapped in forest interior	3
Family CERCOPITHECIDAE						
4	*Macaca fascicularis* (Raffles, 1821)	Long-tailed Macaque	Native, non-endemic	locally common to uncommon and hunted heavily as food, as pets, and for medical research, Least Concern	Observed in forest canopy, Seen in groups	7
Family VIVERRIDAE						
5	*Viverra tangalunga* Gray, 1832	Malay Civet	Native, non-endemic	Moderately common in lowland forest and mixed secondary forest/agriculture mosaic, Least Concern	Fecal droppings observed along transect	Indirect Sign

Famiy SUIDAE						
6	*Sus oliveri* Groves, 1997	Oliver's Warty Pig	Native, **Mindoro Endemic**	Heavily hunted and Increasingly rare, **Vulnerable** (IUCN), **Endangered** (DAO 2019-09)	Wallows observed along transect	Indirect Sign
Family CERVIDAE						
7	*Rusa marianna* (Desmarest, 1822)	Philippine Brown Deer	Native, **Philippine Endemic**	Locally common in isolated areas, but heavily hunted and declining over most of the range, **Vulnerable** (IUCN), **Endangered** (DAO 2019-09)	Footprints observed along transect	Indirect Sign
Total Individuals Observed						**21**
Total Species Observed						**7**

The study also found several ecologically important mammalian vertebrates. Indigenous species contributed 85.71% (six out of seven species) to the composition of observed mammals. Endemic species included two Mindoro endemics and one Philippine endemic. Thus, revealing an endemism percentage of 42.85% (three out of seven species). Regarding the conservation status, only two species were included in the IUCN Redlist of Threatened Species (IUCN, 2022) and DAO 2019-09 (DENR, 2019). Notable among these ecologically important species were the *S. oliveri* and *R. marianna*, both endemic and threatened species (IUCN: Vulnerable; DAO 2019-09: Endangered).

Herpetofaunal Diversity and Composition

Thirty-nine individuals from eight species and seven families were recorded during the survey (Table 3). The most dominant family in terms of the number of individuals was Megophryidae with 17 individuals from its lone documented species in the area, *Leptobrachium mangyanorum* Brown, Siler, Diesmos and Alcala, 2010, making it the most abundant species as well. In terms of the number of taxa, the family Ceratobatrachidae had the highest count with 2 species. All species were personally observed except for *Varanus bangonorum* Welton, Travers, Siler & Brown, 2014 which was recorded through the interview from the local community. The documented herpetofaunal species were associated with forest streams and forest floors. In terms of diversity, the computed H' was 1.539 and the Simpson Evenness was 0.74.

Table 3. Taxonomic list of herpetofauna species found in 2-ha PBMA with corresponding residency status, population and threat statuses, observation notes, and abundance

No.	Species	Common Name	Residency Status	Population and threat status	Observation Notes	Abundance
Family CERATOBATRACHIDAE						
1	*Platymantis dorsalis* (Duméril, 1853)	Dumeril's Wrinkled Ground Frog	Native; **Philippine Endemic**	Common, Least Concern (LC)	Captured and heard in forest stream and along forest floor	8

2	*Platymantis corrugatus* (Duméril, 1853)	Rough-back Forest Frog	Native; **Philippine Endemic**	Common, LC	Captured and heard in forest stream and along forest floor	7
Family MEGOPHRYIDAE						
3	*Leptobrachium mangyanorum* Brown, Siler, Diesmos and Alcala, 2010	Eastern Spadefoot Toad	Native; **Mindoro Endemic**	Not Evaluated in IUCN; **Other Threatened Species (OTS)** in DAO 2019-09	Captured along forest stream	17
Family RANIDAE						
4	*Pulchrana mangyanum* (Brown and Guttman, 2002)	Mindoro True Frog	Native; **Mindoro Endemic**	Common, IUCN: **Endangered**	Captured along forest stream	6
Family GEKKONIDAE						
5	*Gekko gecko* (Linnaeus, 1758)	Tokay Gecko	Native; non-endemic	Common, LC; DAO 2019-09: **OTS**	Captured along forest stream	1
Family VARANIDAE						
6	*Varanus bangonorum* Welton, Travers, Siler & Brown, 2014	Mindoro Water Monitor	Native; **Mindoro Endemic**	Not yet assessed in IUCN; **OTS** in DAO 2019-09	Based on interview, found in all habitat types	from inter view
Family COLUBRIDAE						
7	*Rhabdophis spilogaster* (F. Boie, 1827)	Boie's Keelback	Native; **Philippine Endemic**	Common, LC	Captured along forest stream	1
Family ELAPIDAE						
8	*Hemibungarus calligaster* (Wiegmann in Meyen, 1835)	Philippine False Coral Snake	Native; **Philippine Endemic**	Common, LC	Captured along forest stream	1
Total Individuals Observed/Recorded						**39**
Total Species Observed/Recorded						**8**

In terms of ecological importance, several species had critical and essential statuses. All species (100%) were considered native or indigenous to the Philippines. Moreover, seven out of eight species (87.5%) were endemic of which four were Philippine endemics and three were Mindoro endemics. Lastly, the conservation status assessment revealed four threatened species (57.14% of threatened), including one internationally threatened (endangered based on IUCN) and three nationally threatened (Other Threatened Species based on DAO 2019-09). Notable among this herpetofauna was the *Pulchrana mangyanum* (Brown and Guttman, 2002) which is a Mindoro endemic and endangered species.

Discussion

The number of faunal surveys in the Philippines is beginning to rise due to the threats to biodiversity. This present study in MCWS is one of the pioneer vertebrate faunal research that established permanent biodiversity plots following a national system of biodiversity assessment and monitoring for a long-term conservation and protection of the area and the species therewith.

This study found that MCWS was home to 38 terrestrial vertebrate faunal species (23 birds, 7 mammals, and 8 herpetofauna). Generally, these species were associated with habitat types including forest floors, canopy, streams, grassland, and agricultural lands. This is likely for areas like MCWS which is composed of open or broadleaf forest and patches of grassland and agricultural clearings (Mindoro Biodiversity Conservation Foundation, Inc., 2014). Moreover, the abundant population of forest-dependent birds and fruit bats species can be accounted for the dominant fruit-bearing trees, specifically the large diameter and tall individuals of *S. nitidum*. The food source is really an influential factor that affects the population of wildlife in an area. Similar studies in the Philippines also revealed the presence of abundant bird species and fruit bats due to the presence of fruit trees like *S. nitidum*, basically providing food and shelter for them (Gascon et al., 2013; Heideman & Heaney, 1989).

The computed diversity values of vertebrate fauna were highest for the avian/bird species (H' = 2.78; Simpson Evenness = 0.92). Using the Fernando Biodiversity Scale (Fernando, 1998), these values are interpreted as moderately diverse for Shannon, and very highly diverse for Simpson Evenness. Furthermore, the diversity values obtained for bird diversity in MCWS are relatively higher in studies conducted in various protected areas in the Philippines such as in Mt. Hamiguitan Range Wildlife Sanctuary (H' = 1.25) (Amoroso et al., 2018), Mt. Hamiguitan (H' = 1.098), Mt. Kitanglad (H' = 1.141) and Mt. Malindang (H' = 1.256) (Mohagan et al., 2015). The diversity values obtained for mammals (H' = 1.68; Simpson Evenness = 0.80) and herpetofauna (H' = 1.539; Simpson Evenness = 0.74) were relatively lower. However, these values are also relatively higher than the values obtained in other studies in the Philippines, especially in mammals (Guaza et al., 2016). For the herepetofaunal diversity, the diversity values are lower than in other studies in the country (Gojo Cruz et. al., 2019); this was possibly attributed to the relatively small portion of the riparian ecosystem included in the PBMA. Generally, the vertebrate faunal diversity in the area was commendable.

For ecological importance, MCWS exhibited a high percentage of priority species for conservation such as the native, endemic, and threatened species. Several Philippine endemics and threatened species, such as *S. oliveri* and *R. marianna*, face threats primarily brought by anthropogenic activities. These species were heavily hunted for food; thus, contributing to the rapid decrease in their population (Pawlik, 2021; Pawlik et al., 2014). The other vulnerable species in MCWS experienced loss of habitat due to human disturbance and the impacts of climate change. Thus, dictating the need to maintain and protect the forest cover in the area as it serves as a habitat and food provider for the wildlife species in the area.

Conclusion

MCWS was home to a diverse community of vertebrate fauna. It also exhibited a high percentage of ecologically important species making it a priority area for conservation. The study also revealed many forest-dependent vertebrates of which most depend on the canopy for food and habitat. Thus, implying the need to protect the forests that serve as wildlife habitats. Since the study was conducted on a permanent biodiversity monitoring plot, regular monitoring and strict implementation of forest protection policies must be implemented. It is impossible to note and document all faunal species in a single survey given their ability to move from one place to another, thus, continuous monitoringwill help in achieving an updated list of species together with their status and other necessary information. This will help in crafting more effective and comprehensive conservation and management plans.

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References

Amoroso, V. B., Mohagan, A. B., Coritico, F. P., Lagunday, N. E., Yorong, A. P., Colong, R. D., and Ponce, R. G. (2018). Avifaunal Assemblage in the expansion sites f the Mt. Hamiguitan Range Wildlife Sanctuary, Mindanao, Philippines. *Nature Research Conservation*, 3 (2): 103–109.

Biodiversity Management Bureau. (2015). *Guidebook to Protected Areas of the Philippines.* Biodiversity Management Bureau – Department of Environment and Natural Resources, Philippines.

Biodiversity Management Bureau and the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH. (2017). *Manual on Biodiversity Assessment and Monitoring System for Terrestrial Ecosystems*. BMB and GIZ GmbH.

BirdLife International. (2020). *Important Bird Areas factsheet: Mt. Calavite*. https://www.birdlife.org.

DENR. (2019). *DAO 2019-09.* Department of Environment and Natural Resources.

Fernando, E. (1998). *Forest formations and flora in the Philippines: Handout in FBS 21*. Philippines: University of the Philippines College of Forestry and Natural Resources. (Unpublished).

Gascon, C. N., Garcia, R. C., Beltran, F. N., Faller, W. C., & Agudilla, M. A. R. (2013). Biodiversity assessment of Mt. Banahaw de Dolores, Philippines. *Asian Journal of Biodiversity*, *4*(1), 23-45.

Gatumbato, E. A. (2009). *Mindoro Biodiversity Conservation Program Thrusts: Promoting Shared Responsibility towards the Conservation of Mindoro's Biological and Cultural Diversity*. Mindoro Biodiverstiy Conservation Foundation Inc.

Gojo Cruz, P. H. P. G., Afuang, L. E., Gonzalez, J. C. T., & Gruezo, W. S. (2019). Distribution and diversity patterns of herpetofauna in the Pantabangan-Carranglan Watershed, Nueva Ecija, Caraballo Mountain Range, Philippines. *Biodiversity Data Journal*, (7).

Guaza, M. C. P., Yap, K. M. L., Singson, S. G. T., Nor, S. P., Amado, R. L., Torres, M. A. J., Non-Cabrera, M. L., and Requieron, E. A. (2016). Comparative diversity and composition of small non-volant mammals in areas found on Soccsksargen Region, Philippines. *Journal of Biodiversity and Environmental Sciences* 8 (2): 255-264.

Hammer, Ø., Harper, D. A., & Ryan, P. D. (2001). PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia electronica*, *4*(1), 9.

Heideman, P., & Heaney, L. (1989). Population biology of fruit bats (Pteropidae) in Philippine submontane rainforest. *Journal of Zoology, 218*(4), 565-586.

Ingle, N. and Heaney, L. (1992). *A key to the bats of the Philippine Islands.* Fieldiana.

IUCN. (2022). *The IUCN Red List of Threatened Species Version 2021-3.* International Union for Conservation of Nature. https://www.iucnredlist.org/.

Kennedy, R., Gonzales, P. C., Dickinson, E., Miranda Jr, H. C., & Fisher, T. H. (2000). *A guide to the birds of the Philippines*. Oxford University Press.

Lee, W., Mcglone, M., Wright, E., Rutledge, D., Wilson, D., Norbury, G., Overton, J., Wiser, S., West, C., Colin, O., Wright, D., and Stephens, T. (2005). *Biodiversity Inventory and Monitoring: A review of national and international systems and a proposed framework for future biodiversity monitoring by the Department of Conservation*. Landcare Research New Zealand Ltd.

Matsubayashi, H., Boyles, R., Salac, R., Barrio, B., Cruz, L., Garcia, R., Ishihara, S., and Kanai, Y. (2010). Present Status of Tamaraw (Bubalus mindorensis) in Mt. Aruyan, Mindoro, Philippines. *Tropics* 18: 167-170.

Mindoro Biodiversity Conservation Foundation Inc. (2014). *Mt. Calavite Wildlife Sanctuary Resource and Socio-Economic Assessment (RSEA) Final Report*. Muntinlupa City: Mindoro Biodiversity Conservation Foundation Inc.

Mohagan, A. B., Nuñeza, O. M., Gracia, A. G., Selpa, E. C. T., Escarlos, J. A. Jr., Baguhin, L. J. B., Coritico, F. P., & Amoroso, V. B. (2015). Species richness of avifauna in four Long Term Ecological Research sites in Mindanao, Philippines. *Journal of Applied Environmentaland Biological Sciences*, 5 (11): 88–89.

Mahmoodzadeh, A. ., Eisapoor, S. S. ., & Mirghiasy, S. A. . (2022). Biodiversity in the third millennium. Scientific Reports in Life Sciences, 3(2), 1–14. https://doi.org/10.5281/zenodo.6840509

NORDECO and DENR. (2001). *Biodiversity Monitoring System Manual for Protected Areas*. Second edition. DENR, Manila, and NORDECO, Copenhagen.

Pawlik, A. F. (2021). Technology, adaptation, and mobility in maritime environments in the Philippines from the Late Pleistocene to Early/Mid-Holocene. *Quaternary International*, *596*, 109-123.

Pawlik, A. F., Piper, P. J., Faylona, M. G. P. G., Padilla, S. G., Carlos, J., Mijares, A. S., Vallejo, B., Reyes, M., Amano, N., Ingicco, T., & Porr, M. (2014). Adaptation and foraging from the

terminal Pleistocene to the early Holocene: excavation at Bubog on Ilin Island, Philippines. *Journal of Field Archaeology*, *39*(3), 230-247.

Pereira, H., Belnap, J., Böhm, M., Brummitt, N., Garcia Moreno, J., Gregory, R., Martin, L., Peng, C., Proença, V., Schmeller, D., and Swaay, C. (2017). Monitoring Essential Biodiversity Variables at the Species Level. In: Walters M., Scholes R. (Eds.), *The GEO Handbook on Biodiversity Observation Networks*. Springer.

Shannon, C. E. (1948). A mathematical theory of communication. *The Bell system technicaljournal*, *27*(3), 379-423.

Simpson, E. H. (1949). Measurement of diversity. *Nature*, *163*(4148), 688-688.

Singh, M. (2020). Evaluating the impact of future climate and forest cover change on the ability of Southeast (SE) Asia's protected areas to provide coverage to the habitats of threatened avian species. *Ecological Indicators*, *114*, 106307. https://doi.org/10.1016/j.ecolind.2020.106307.

Von Rintelen, K., Arida, E., & Häuser, C. (2017). A review of biodiversity-related issues and challenges in megadiverse Indonesia and other Southeast Asian countries. *Research Ideas and Outcomes*, *3*, e20860. https://doi.org/10.3897/rio.3.e20860.

Zapanta, B. R., Achondo, M. J. M. M., Raganas, A. F. M., Fritzie, A., Delima, A. G. D., Mantiquilla, J. A., & Salvaña, F. R. P. (2019). Species richness of trees in disturbed habitats within a protected area and its implications for conservation: The case of Mt. Apo Natural Park, Mindanao Island, Philippines. *Biodiversitas Journal of Biological Diversity*, *20*(7), 2081-2091. https://doi.org/10.13057/biodiv/d200740.

Figure S1. Representative wildlife vertebrate species captured within the PBMA. Top (l-r): Indigo-banded Kingfisher (*Alcedo cyanopectus*), Red-bellied Pitta (*Erythropitta erythrogaster*); middle (l-r): Common short-nosed fruit bat (*Cynopterus luzoniensis*), Musky fruit bat (*Ptenochirus jagorii*); bottom (l-r): Mindoro True Frog (*Pulchrana mangyanum*), Eastern Spadefoot Toad (*Leptobrachium mangyanorum*)