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Species Diversity of Bats in Clarin River, Misamis Occidental, Philippines

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Abstract

Bats display indispensable role in the balance of the ecosystem, from pollinating flowers and eating pest to dispersing seeds of plant species that depend entirely on bats for distribution. Bats are present in almost all habitats ranging from seaside, caves, mountains, and rivers. Clarin river is one of the freshwater bodies draining from the biodiverse Mt. Malindang that hosts a large number of flora and fauna. Riparian fauna along Clarin River is not yet assessed which is the main objective of this study. Bat fauna along the upstream, middle stream and downstream of Clarin river was assessed through mist netting to provide baseline data on the species composition and distribution of bats in the area. Ten species of bats were documented in the area of which four are endemic. The highest relative abundance was observed in upstream with a value of 39.38% and the highest species diversity was recorded in the midstream with diversity index of H' = 1.748. The results of the study may provide baseline data on the species composition and distribution of bats in the area that can be used by the local government and other agencies in conserving bats.

Keywords: abundance, ecosystem, endemic, fauna, freshwater

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Introduction

Bats provide many important ecosystem services such as control of insect pests, pollination, and dispersal of seeds (Maas et al., 2016; Corlett, 2016; Costa et al., 2018). Therefore, they play an essential role in the maintenance and regeneration of forests and also for the well-being of bat-dependent fruit trees. Moreover, they are considered as bioindicators of the quality of an ecosystem (Stahlschmidt & Brühl, 2012).

In the Philippines, Chiroptera is the most diverse order of mammals with 78 known bat species belonging to six families (Heaney et al., 2018). Twenty-five species are represented in the country and these include the most abundant and most easily captured mammals. Moreover, 48 species of insectivorous bats are known to occur in the Philippines. Insectivorous bats use a highly sophisticated and sensitive echolocation to navigate, and this system often allows them to evade mist nets set to capture them. As a result, they are often the least-well known mammals in any given region (Heaney, 2002).

Philippines is very rich in terms of its biological diversity considering its small geographic area (Ambal et al., 2012). Mindanao, being the second largest island in the Philippine archipelago, has extensive lists of interesting flora and fauna in which some are endemic to the island (Enriquez & Nuñeza, 2014; Nuñeza & Galorio, 2014; Supsup et al., 2017; Cabras et al., 2017). In Mindanao region, there are a total of 53 known bat species, fewer than five bat families of which three species are known to be distributed only in the Mindanao Islands including *Alionycteris paucidentata* and *Ptenochirus minor,* both under the Family Pteropodidae, and *Hipposideros coronatus* of the Family Rhinolophidae (Ingle et al., 1999).

Bats inhabit varied sets of habitats ranging from forest, agricultural area, urban, and riparian habitats (Kunz & Fenton, 2005). Riparian habitats including rivers are important habitats for several bat species by providing them food, water and is widely accepted that bat foraging activity is commonly greatest in these areas (Racey, 1998).

Mt. Malindang is one of the mountain ranges that caters high faunal diversity with a land area that covers 53,262 hectares in which the forest covers about 33,000 hectares, and the remaining portion of more than 20,000 hectares are opened and occupied by about 4,000 families of whom some are indigenous people. The Mt. Malindang Range is a watershed or catchment area which drains water through 49 rivers and streams, and numerous creeks. It provides potable water for domestic, agricultural, and other uses to more than one million inhabitants of Misamis Occidental and the eastern parts of Zamboanga del Norte and Zamboanga del Sur.

Mt. Malindang is biologically and ecologically significant as a home to many rare, endemic, and endangered species of plants and animals. However, its biodiversity has been severely threatened due to forest loss (Nuñeza et al., 2010). Intensification in land-use and farming practices has had largely negative effects on bats, leading to population declines and loss of ecosystem services (Williams-Guillén et al., 2016).

Clarin river is a freshwater body draining from the biodiverse Mt. Malindang that hosts a large number of flora and fauna. It forms a natural boundary between the city of Ozamiz and the municipalitiy of Clarin (Labajo-Villantes & Nuñeza, 2015). Riparian fauna along Clarin river, specifically bats are not yet assessed which is the main objective of this study. This research study aimed to determine the species diversity of bats in Clarin river in Misamis Occidental. Specifically, the study aimed to identify the bat species present in the area, determine the species richness, relative abundance, distribution, endemism as well as their conservation status. The results of the study may provide baseline data on the species composition and distribution of bats in the area that can be used by the local government and other agencies in conserving bats.

Materials and Methods

Sampling area

Clarin River is one of the major river systems in the province of Misamis Occidental situated along the boundary of the city of Ozamiz and the municipality of Clarin in Misamis Occidental, with coordinates

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of 123°37'30" to 123°13'10" E and 8°7'30" to 8°13'10" N (Figure 1). The study area was divided into three sampling sites: the downstream, midstream, and the upstream of the river. Elevation and coordinates of the sampling sites were noted. The first sampling site is located at the downstream of Clarin River (900-1200 masl, 08^0 43' 142" N and 125^0 02' 185" E) located within Barangay Pan-ay in Clarin. Permission from the Department of Environment and Natural Resources and the local government of Clarin was secured before the conduct of the study.

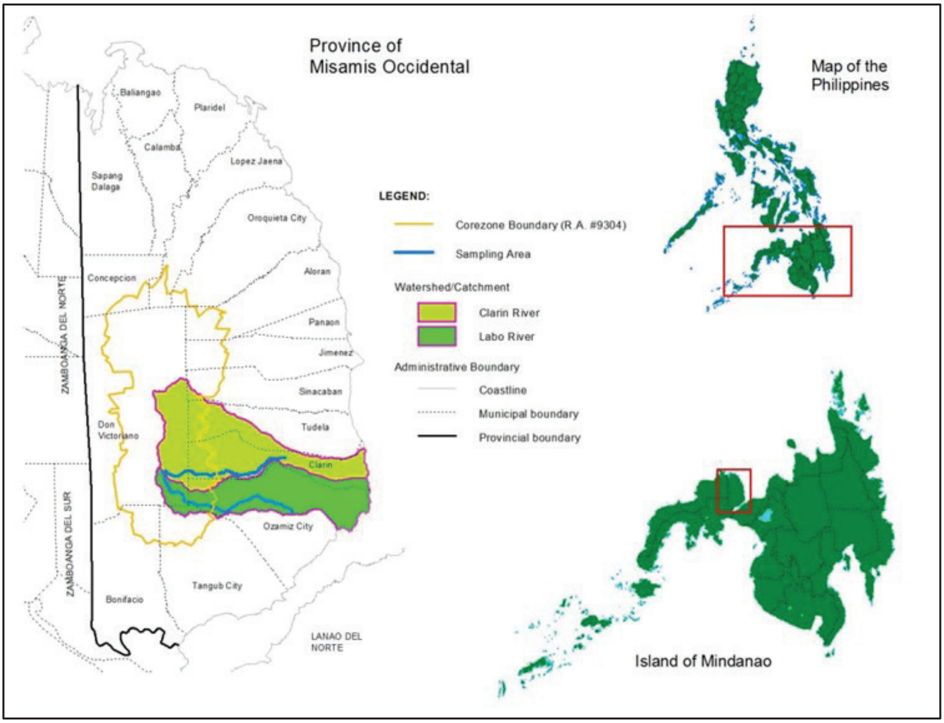

Figure 1. **Map showing Clarin River in Misamis Occidental, Philippines (Source: https://www.google.com/maps).**

The area is mostly dominated by agricultural crops and fruit trees such as marang (*Artocarpus odoratissimus*), guava (*Psidium guajava*), coconut (*Cocos nucifera*), Breadnut (*Artocarpus camansi*), Java plum

(*Syzigium cumini*), banana (*Musa spp.*), corn (*Zea mays*) and Mango *(Mangifera indica)*. Bamboos (*Bambusa spp.*) and other non-fruiting trees such as Molave Tree (*Vitex parviflora*) and *Gmelina arborea* were observable in the area. The ground is mostly covered by ferns, grasses and shrubs. Anthropogenic influences were observed in the area being situated near households.

The second sampling is located the midstream of the river (900-1200 masl, 08^0 43' 142" N and 125^0 02' 185" E) situated within Barangay Guba in Clarin. Fruit plants observable along the area were Guyabano (*Anona muricata*), star apple (*Chrysophyllum cainito*), banana (*Musa* spp.), guava (*Psidium guajava*), "marang" (*Artocarpus odoratissimus*), mango *(Mangifera indica)*, and coconut (*Cocos nucifera*). Indian almond, commonly known as talisay (*Terminalia catappa*), *Gmelina arborea*, and banyan (*Ficus* spp.) are noted in the area. Bamboos (*Bambusa* spp.) were found along the river. Carabao grass (*Paspalum conjugatum*) and different species of ferns dominated the ground cover.

The third sampling site is located at the upstream of the river (900-1200 masl, 08^0 43' 142" N and 125^0 02' 185" E) located within Barangay Stimson Abordo in Ozamiz. Tree taxa present in the area were Malay apple (*Syzygium samarangense*), breadnut (*Artocarpus camansi*), banana (*Musa* spp), "marang" (*Artocarpus odoratissimus*), cottonfruit, commonly known as santol (*Sandoricum koetjape*), wild coffee (*Coffea* spp.), and sweet palm fruit, also known as "kaong" (*Arenga pinnata*). Acacia tree (*Acacia* spp.), "banyan" (*Ficus* spp.) and *Gmelina arborea* were also found to be present in the area. Ferns and grasses comprised the ground cover.

Sample collection

Bats were captured using nylon and polyester mist-nets and released immediately after they were examined, measured, and identified. Mist-nets were placed along flight paths, across trails, and along the river to maximize capture success. The nets were opened shortly before dusk and were monitored early in the evening with two to three hours interval throughout the night depending on the accessibility of the area. Captured

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bats were placed in cloth bags. Distinctive morphometric measurements of bats were taken such as: forearm length, hind foot length, tail length, ear length, body length and total body length useful for identification. Age of bats wa determined by stretching the wing of the bat, noting on the partly translucent bands of cartilage which indicates that the bat is a juvenile and adult if the bat has fully ossified bones and joints that appear opaque (Churchill,1998). Bats released were marked so as not to count them when recaptured. Ingle & Heaney (1992) were used as reference in the identification of bats up to the species level.

Data analysis

Biodiversity indices were computed using the Paleontological Statistics (PAST) Software. Evenness measures the distribution of individuals among species in an area and the value is equal to one if the species are equally abundant and no species dominates upon the other (Monteclaro & Nuneza, 2015). Endemism and conservation status of bats were determined based on the IUCN (2018).

Results and Discussion

Ten species of bats were documented in the three sampling sites of Clarin river signifying 12% of the total Philippine bat species, with 391 individuals belonging to nine genera and three families in which four are endemic with one Mindanao endemic and four non-endemic (Table 1). As shown, there are seven fruit bat species under family Pteropodidae: *Cynopterus brachyotis, Dyacopterus spadicius, Eonycteris robusta, Macroglossus minimus, Ptenochirus jagori, Ptenochirus minor,* and *Rousettus amplexicaudatus*. Three species are insectivorous under the families Vespertillionidae: *Myotis* sp. and *Kerivoula* sp., and Rhinolophidae: *Rhinolopus subrufus*.

Of the ten species of bats documented, four are endemic with 40% endemism (Table 2). Three are Philippine endemics (*E. robusta, P. jagori, R. subrufus*) and one is a Mindanao faunal region endemic (*P. minor*). Endemic bat species as noted by Sewall et al. (2013), are known to be sensitive to disturbances.

Table 1. Bat species recorded in Clarin River, Misamis Occidental and their common names, distribution, and conservation status.

Family/Species (S.N.)	Common Name	Distribution	Conservation Status (IUCN, 2018)
Pteropodidae			
Cynopterus brachyotis	Lesser Dog-faced Fruit Bat	Non-endemic	Least Concern
Dyacopterus spadiceus	Dayak Fruit Bat	Non-Endemic	Near Threatened
Eonycteris robusta	Philippine Dawn Bat	Philippine Endemic	Near Threatened
Macroglossus minimus	Dagger-toothed Long-nosed Fruit Bat	Non-endemic	Least Concern
Ptenochirus jagori	Greater Musky Fruit Bat	Philippine Endemic	Least Concern
Ptenochirus minor	Lesser Musky Fruit Bat	Mindanao Endemic	Least Concern
Rousettus amplexicaudatus	Common Rousette	Non-endemic	Least Concern
Rhinolophidae			
Rhinolophus subrufus	Small Rufous Horseshoe Bat	Philippine Endemic	Data Deficient
Vespertilionidae			
Kerivoula sp.	Bent-winged/Long-winged Bat	N/A	N/A
Myotis sp.	Vesper bat	N/A	N/A

Table 2. List and relative abundance of bats in Clarin River, Misamis Occidental.

Species	Site 1	Site 2	Site 3	Total
Cynopterus brachyotis	21 (18.58%)	41 (33.06%)	36 (23.37%)	98 (25.06%)
Dyacopterus spadiceus	0	0	7 (4.54%)	7 (1.79%)
Eonycteris robusta	1 (0.88%)	0	7 (4.54%)	8 (2.04%)
Macroglossus minimus	5 (4.42%)	12 (9.67%)	8 (5.19%)	25 (6.39%)
Ptenochirus jagori	36 (31.85%)	34 (27.41%)	59 (38.31%)	129 (32.99%)
Ptenochirus minor	13 (11.50%)	15 (12.09%)	16 (10.38%)	44 (11.25%)
Rousettus amplexicaudatus	35 (30.97%)	7 (5.64%)	21 (13.63%)	63 (16.11%)
Rhinolopus subrufus	0	4 (3.22%)	0	0
Kerivoula sp.	0	4 (3.22%)	0	0
Myotis sp.	2 (1.76%)	7 (5.64%)	0	9 (2.30%)
Total number of individuals	113 (28.90%)	124 (31.71%)	154 (39.38%)	391

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The bat species recorded common in all sampling areas were *Cynopterus brachyotis*, *Rousettus amplexicaudatus,* and the Philippine endemics *Ptenochirus jagori* and *Ptenochirus minor*. *Ptenochirus jagori* also known as the Greater Musky Fruit Bat is the most abundant bat species with 129 individuals recorded with relative abundance value of 32.99% which is attributable to the abundance of food for these bat species in the area. *Ptenochirus jagori* and *P. minor* were also documented in Cagayan de Oro River (Lobite et al., 2013). As reported by Monteclaro & Nuneza (2015), this species of bat roosts in hollow trees and is known to rely heavily on figs and *Musa* plant species which are abundant in the area explaining its significant number in the study area. As noted by (Heaney et al., 2006), *P. jagori* is a Philippine endemic and *P. minor* is endemic to the Mindanao faunal region, commonly found in disturbed lowland forests and agricultural areas explaining its accounted relative abundance in this area.

Cynopterus brachyotis, also known as the Lesser Dog-faced Fruit Bat and *Rousettus amplexicaudatus*, the Common Rousette fruit bat were found to be present in all sampling locations attributed to the availability of the fruit plants they forage on such as the *Musa* species. These species of bats were also found to be abundant in Cagayan de Oro River (Lobite et al., 2013). According to Tan et al. (1998), *C. brachyotis* is highly adaptive to its environment and can occupy various habitats such as primary rainforest, mangrove swamps, cultivated areas, orchards, urban and other disturbed anthropogenic areas which explain its abundance in all sampling sites. The presence of *R. amplexicaudatus*, a cave dwelling bat species (Francis, 2010), in all sampling sites despite the absence of caves in the area can be accounted to the abundance of fruit trees they primarily feed on. Fruit trees may have been an attraction to this bat species allowing it to move long distances to explore variety of habitats and feeding grounds (Fenton, 1997) explaining its presence in all sampling areas.

Dyacopterus spadiceus, commonly known as Dayak Fruit Bat, a near threatened bat species was found only in the upstream of Clarin river. Nuneza et al., (2015) documented *D. spadiceus* in a lowland area near a riverine system. The presence of *Macroglossus minimus*, commonly known as Dagger-toothed Flower Fruit Bat, in all sampling locations can be attributed to the abundance of banana (*Musa spp).* in the area. This bat species according to Heaney et al. (2006), is strongly associated with domestic and wild banana *Musa spp.* and is widely distributed in every habitat in the Philippines, often found to be abundant in agricultural and disturbed areas.

Three species of insect bats were recorded in the area, *Rhinolopus subrufus* and two species belonging to the genera *Kerivoula* and *Myotis*. The very low number of captured individuals of insect bats is attributable to the fact that insect bats are difficult to capture due to their capability to echolocate. As noted by Heaney et al. (2002), insectivorous bats use highly sophisticated and sensitive system of echolocation, and that this system often allows them to evade mist nets in any given region. Thus, the mist netting method used is not very efficient in capturing insect bats and is one factor that contributed to the low number of captured insect bats.

As shown in Table 3, the highest species richness was noted at sampling site 2 with eight species captured compared to sampling sites 1 and 3 with six and seven species, respectively. High species richness of bats in the area could be attributed to the type of vegetation present, variety of food resources in the area, and tree roosting preferences of bats. Elevation of the sampling sites can be one of the factors affecting species richness of the bats. As noted by Heaney et al. (2006), bat species tend to decrease in richness with increasing elevation. This observed pattern is attributable to temperature. Higher temperature in lowland areas result to higher bat species richness which declines as temperature decreases (McCain, 2007). The observed species richness of insect bats in sampling sites 1 and 2 can be attributed to their low elevation. Areas of low elevation according to Angell et al. (2013) support large population of insects due to its stable and higher temperature making them ideal sites for insectivorous bats to forage.

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Table 3. Biodiversity indices of the bat fauna in Clarin River, Misamis Occidental.

Sites	Individuals	RA (%)	Richness	Diversity	Evenness	Dominance
1	113	28.9	6	1.54	0.665	0.2476
2	124	31.7	8	1.748	0.7181	0.217
3	154	39.3	7	1.649	0.7431	0.2376

The low number of bat species observed in sampling site 1 appears to be due to the observed anthropogenic disturbances brought about by the people living in the area and the conversion of a portion of the downstream of Clarin river into a quarry site. Disturbance according to Hobbs and Huenneke (1992) affects structural and habitat diversity as well as the overall species diversity in an area.

The highest relative abundance per sampling site was observed in sampling site 3 with a value of 39.38% followed by sampling site 2 with a value of 31.71% which is attributed to the type of vegetation present in the area. Abundance can be influenced greatly by food availability as well as habitat types (Maryanto & Yani, 2003). A low relative abundance (28.90%) was recorded in sampling site 1 which is probably due to the observed anthropogenic disturbances in the area.

Of the three sampling sites, sampling site 2 had the highest species diversity with a species diversity value of H' = 1.748. The abundance of fruit-bearing trees in sampling site 2 supports the observed high species diversity in the area. The observed low species diversity in sampling site 1 can be due to the observed anthropogenic disturbances in the area. Species diversity values obtained indicate that Clarin River has moderate species diversity of bats. Sampling sites 2 and 3 showed close species evenness values of 0.7181 and 0.7431, respectively, while sampling site 3 had species evenness value of 0.665. Results indicate even distribution of bat species in the area and that there are no dominant species. Evenness is negatively affected by increasing species richness and that the differences in resource availability at sites with lower environmental stress can explain the negative effects of richness on evenness (Estrada-Villegas et al., 2012).

Conclusion and Recommendation

Clarin River has moderate species diversity of bats and can still sustain these species despite the fact that it is already disturbed. However, continued forest destruction in the area could lead to the loss of bat species. The presence of endemic and near threatened bat species in the study area highlights the importance of conservation. It is recommended that biodiversity awareness campaign on the diversity and status of bat fauna be done in Clarin River to help prevent the loss of bat species.

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