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Species diversity of bats in Mt. Matutum protected landscape, Philippines

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Abstract

Bats are particularly the most diverse in tropical regions that play an important role in the ecosystem. To determine species diversity and endemism of bats, this study was conducted from August to December 2013 in six sampling sites in Mt. Matutum Protected Landscape. Mist nets were established at different elevations in disturbed and undisturbed habitats. Fifteen species belonging to four families were documented, representing 19% of the total Philippine bat species with 47% endemism. Only one vulnerable species *Megaerops wetmorei* was documented. Species diversity was higher in sampling sites which are relatively undisturbed. Fruit bats were the dominant group where the widespread *Cynopterus brachyotis* was the most abundant. Kruskal-Wallis test revealed significant differences between species diversity in disturbed and undisturbed sites while no significant difference in species evenness was observed. The presence of endemic and vulnerable species indicates the need to strengthen conservation initiatives in Mt. Matutum.

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Introduction

The Philippines, an archipelago of 7,107 islands with a total land area of around 30 million hectares (Chokkalingam *et al.,* 2006) possesses a wealth of biological diversity and an exceptionally high degree of endemism (Heaney *et al.,* 2006). The Philippines has natural resources that include rare plants and endemic animals (Rickart *et al.,* 2007) that are dependent on natural forest habitat. There is a high level of mammalian diversity with more than 185 species of terrestrial mammals (Duya *et al.,* 2011) of which 78 are bat species (Heaney *et al.,* 2010) with 24 endemic species (Ingle and Heaney, 1992). However, the unique biodiversity of the country has been put under great pressure because the rich natural resources are depleting at an alarming rate (Heaney and Regalado, 1998) due to continuous destruction and exploitation of the natural resources (Ambal *et al.,* 2012). The country has suffered widespread deforestation and, across the archipelago, only 20% of original forest cover remains (Posa *et al.,* 2008) which caused the dramatic increase in the number of endangered mammalian species (Heaney and Regalado, 1998) thus it is regarded by nearly every major international conservation organization as one of the top global priorities for conservation action (Oliver and Heaney, 1997). Despite the rapid destruction of the country's forest, there are still new species of plants and animals (primarily amphibians and mammals) which are still being discovered (Alcala *et al.,* 2006). A new species of Stripe-faced Fruit Bat (Chiroptera: Pteropodidae: *Styloctenium*) from the Philippines (Esselstyn, 2007) and a new species of *Desmalopex* (Pteropodidae) also from the Philippines (Esselstyn *et al.,* 2008) were found and described. Other discoveries of bats in the country were also reported by O'malley *et al.* (2006); Sedlock *et al.* (2008); Heaney *et al.* (2012) and Lobite *et al.* (2013).

Bats (Order: Chiroptera) are particularly the most diverse and abundant in tropical regions (Murray and Kunz, 2005). In the Philippines, order Chiroptera is known to be one of the most diverse mammalian orders (Ingle and Heaney, 1992) with 25 megachiropteran and 48 microchiropteran species (Heaney and Regalado, 1998). This diversity is shown in the study conducted in the caves of Sierra Madre Natural Park by Cabauatan *et al.* (2014) and in Polillo Islands by Alviola (1999) who recorded 25 bat species while Sedlock *et al.*, (2008) documented 26 bat species in the tropical forest and agro-pastoral habitats within a protected area in the Philippines. Bats also play an important ecological role in arthropod suppression (Veikkolainen *et al.*, 2014), as prey and predator, in material and nutrient cycling and distribution (Kasso and Balakrishnan, 2013) apart from their role as seed dispersers and natural pollinators of the forest (Kunz *et al.*, 2011). Bats are also excellent and important ecological indicators of habitat quality because they are sensitive to a wide range of environmental stresses to which they respond in predictable ways. Their wide range of food sources have allowed them to be used as indicators for a wide range of environmental stressors (Jones *et al.*, 2009).

Despite the importance of the bats to our ecosystem, data for monitoring the conservation status of bats in the Philippines are very limited (Mould, 2012) which have led to an acute lack of quantitative data on abundances and how environmental change may affect them (Mallari *et al.,* 2011). Recent studies have been reported by Achondo *et al.* (2014) on the occurrence and abundance of fruit bats in North Cotabato; Abantas and Nuñeza (2014) on the species diversity of bats in cave ecosystem in Tagoloan, Lanao del Norte; Galorio and Nuñeza (2014) on cave bats in Bukidnon and Davao Oriental; Nuñeza and Galorio (2014) on cave bats in Siargao Island; Cabauatan *et al.* (2014) on bats in Sierra Madre Natural Park; and Monteclaro and Nuñeza (2015) on fruits in Bega Watershed, Agusan del Sur.

Mt. Matutum, a protected landscape, hosts diverse plant and animal species consisting of 110 plant species and 57 animal species including the Philippine Eagle (UNESCO, 2006). Garciano *et al.*

(2014) reported on the species richness of spiders in Mt. Matutum but the only available data on bat species in Mount Matutum Protected Landscape (MMPL) are unpublished reports. This study was conducted to determine the species diversity, endemism, abundance and conservation status of bats at different elevations of Mt. Matutum.

Materials and methods

Study Area

This study was conducted in Mt. Matutum, South Cotabato (Fig. 1). MMPL is located in the southeastern part of Mindanao, encompassing South Cotabato, Sarangani, and General Santos City, and known as SOCCSKSARGEN region. Six samplings were done at six different sampling areas. Three sampling sites which are considered disturbed sites were established at three elevations representing the lowland dipterocarp, montane, and mossy forests. Three sampling sites which are identified as relatively undisturbed sites were also established at three elevations.

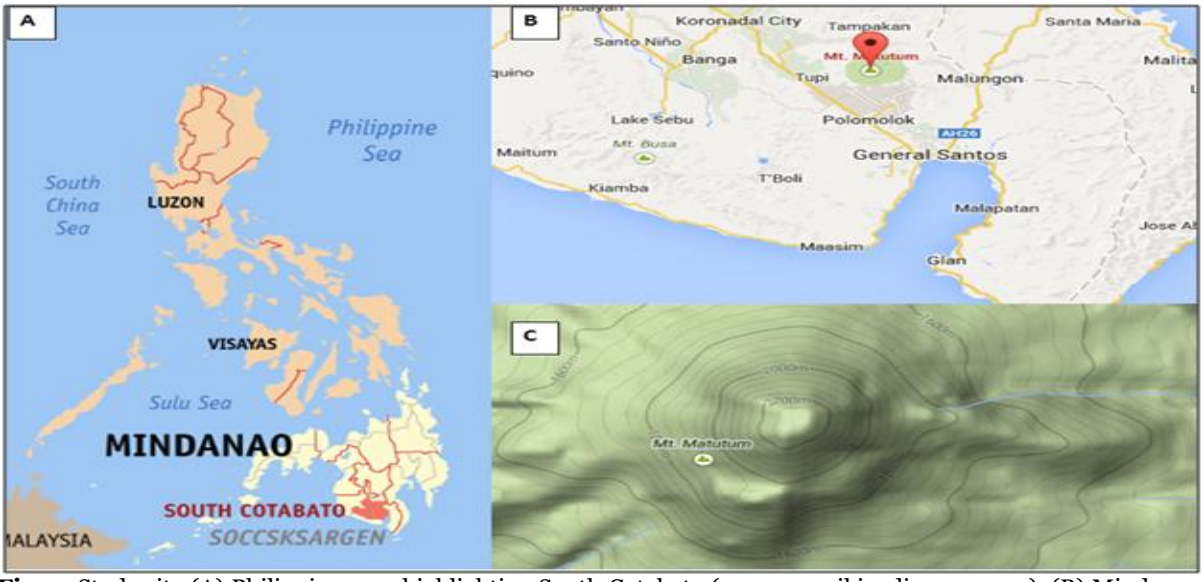

Fig. 1. Study site (A) Philippine map highlighting South Cotabato (www.en. wikipedia.org, 2015), (B) Mindanao map showing location of Mt. Matutum (www.google.com.ph/maps, 2015) (C) Top view of Mt. Matutum Protected Landscape (www.google.com.ph/maps, 2015).

Sampling Sites

Site 1 was at Upper Linan, Tupi, South Cotabato. Sampling was conducted for 55 net nights on August 19-23, 2013. The area is known to be a lowland mixed agricultural and secondary forest with elevation range of 500-800 meters above sea level (masl). Soil is loamy with thin leaf litter. Bodies of water like river and stream were observed in the area. Dominant understory flora was "malaropit" (*Elaeocarpus* sp.) while dominant tree was "Buyo-buyo" (*Piper arborescens*). Emergent trees were *Ficus ulmifolia* and *Erythrina subumbrans*. The sampling area was adjacent to an orchard dominated by fruiting durian trees (*Durio zibethinus*), coffee, and corn fields ready for harvesting.

Site 2 was located at Glandang, Tupi, South Cotabato (6˚21'4.1"N, 125˚3'39.6"E). Sampling was conducted for 45 net nights on October 2-8, 2013. The area is a montane secondary growth forest with elevation ranging from 1,323masl to 1,370masl. Soil is loamy with dense cover of leaf litter approximately 1.5 inches thick with surface litter at initial stage of decomposition. Presence of small spring with water deposition in the pond was observed. Dominant understory plant was "osmunda" (*Calamus ornatus*)

while dominant tree was "anislag" (*Securinega flexuosa*). Emergent tree is White Lauan (*Shorea contorta*). Coffee was the most dominant fruiting plants in the area.

Site 3 was located at Glandang, Tupi (6˚21'48"N, 125˚4'15"E) at the mossy forest at elevation of 1600masl-1714 masl. Sampling was done for 45 net nights on December 2-6, 2013. A wide bare loamy ground covered approximately 25% of the sampling area while 25% of the forest floor has dense leaf litter of about 1 to 2 inches thick. Abundance of fallen logs approximately measuring more than 10 cm diameter was observed. Dominant understory plant observed was *Pteridium* sp. while the most dominant and emergent trees were "igim" (*Dacrycarpus imbricatus*). Epiphytes like ferns and wild coffee seedlings were plentiful in the area.

Site 4 was at SitioKawit, Barangay Maligo (6˚20'39.4"N, 125˚6'5.3"E), Polomolok, South Cotabato. Sampling was done for 64 net nights on September 9-15, 2013. The area is a lowland mixed agricultural and secondary forest with elevation of 987-997 masl. Substrate is loamy with thin leaf litter. Small riverine system near the lowest elevated sampling station was observed. Dominant understory plant observed was *Impatiens platypetala* while dominant tree was "anabiong" (*Trema orientalis*) and "buyo-buyo" (*Piper arborescens*). Emergent tree species was "taluto" (*Pterocymbium tinctorium*). Few durian trees, other fruit trees, squash vines, and corn were observed.

Site 5 was at SitioKawit, Barangay Maligo, Polomolok, South Cotabato (6˚21'9.9"N, 125˚4'15"E) at the montane secondary growth forest with elevation of 1325masl-1339 masl. Sampling was done for 52 net nights on October 13-17, 2013. Soil is loamy with dense cover of leaf litter approximately 1.5 inches thick with surface litter at the initial stage of decomposition. Dominant understory plant observed was *Calamus ornatus* while dominant tree species was *Securinega flexuosa*. Emergent trees observed in the area were "agoho del monte" (*Gymnostoma rumphianum*) and "igim" (*Dacrycarpus imbricatus*).

Site 6 was at SitioKawit, Barangay Maligo, Polomolok, South Cotabato (6˚21'21.1"N, 125˚5'8.0"E). Sampling was done for 40 net nights on December 9-13, 2013 in a mossy forest that is partially disturbed with an elevation of 1612 masl-1719 masl. Leaf litter was very dense, approximately more than 2 inches thick with surface litter at initial stage of decomposition. A large part of the area was covered with bryophytes. Dominant understory plants observed were "lagulo" (*Blechnum egregium*) and "pandanbaging" (*Freycinetia maxima*). The dominant and emergent tree species in the area was "igim" (*Dacrycarpus imbricatus*). Bryophytes were abundant on the bark or trees. Dead trees were also observed to be plentiful.

Collection of samples, processing and identification

Mist netting for a total of 301 net nights was employed to collect samples. Body weights of captured bats were taken using Pesola spring balance while morphometrics were taken using vernier caliper. Identification was based on taxonomic key by Ingle and Heaney (1992) and was verified by Danilo Balete and Lawrence Heaney of the Chicago National Field Museum. Conservation status and distribution were based on the IUCN Red List of Threatened Species (2014).

Individuals identified in the field were marked with permanent markers and released after getting the morphometrics. One to two voucher specimens per species particularly those not identified in the field were prepared and deposited at the Mindanao State University-Iligan Institute of Technology Natural Science Museum.

Data analysis

Species richness, relative abundance and endemicity were computed. Biodiversity indices, cluster analysis, and Kruskal-Wallis test were done using Paleontological Statistics Software (PAST) by

Hammer (2012).

Results and discussion

Species Richness and Endemism

Fifteen species of bats with 293 individuals belonging to 11 genera and four families were documented in Mt. Matutum Protected Landscape (Table 1) representing 19% of the total Philippine bat species. This result was higher than the recorded number of bat species on Bega Watershed Agusan del Norte (Monteclaro and Nuñeza, 2015), Panay Island, Philippines (Mould, 2012), Mount Palali, Caraballo, Mountains, Luzon (Alviola *et al.,* 2011) and Danjugan Island, Cauayan, Negros Occidental (O'malley *et al.,* 2006). However, this result was lower than the recorded number of bat species in Mount Isarog Natural Park (Sedlock *et al.,* 2008). Of the 15 species of bats recorded, seven are endemic with 47% endemism. Higher species richness was observed at lower elevations at Site 1 (S=7) and Site 4 (S=11). The higher species richness of bats observed in a lowland dipterocarp forest in MMPL could be due to its vegetation assemblage composed of lowland-mixed agricultural and secondary forest, high canopy, and variety of food resources for bat species. This observation concurs with the findings of van Weerd and Udo de Haes (2010) and McCain (2007) that lowland dipterocarp forest which has high canopy, complex forest structure and variety of food resources for other taxa could harbor high number of bat species. Caro (2006) noted that reduced food availability remains the best reason affecting richness and abundance of mammalian fauna. Moreover, elevation of the sampling site and presence of water availability could be one of the factors for the presence of bat species in an area. According to Heaney (2001) bats are specious in lower elevation and tend to decrease in richness with increasing elevation which in the case of lowland dipterocarp forest of MMPL is characterized by low elevation (500-997 masl) with high water availability. This pattern is attributed by McCain (2007) and Angell *et al.* (2013) to temperature and water availability. Higher temperature and higher water availability in lowland areas result to higher bat species richness which declines as temperature decreases and water availability becomes scarce. Moreover, low-elevation areas support large population of insects due to stable and higher temperature making those ideal sites for foraging of insectivorous bats (Angell *et al.,* 2013).

Cynopterus brachyotis is commonly known as the Lesser Dog-faced fruit bat is the most abundant bat species in MMPL with 124 individuals and a relative abundance of 42.3%, having been encountered in all sampling sites. This species is also abundant in lowland forest and lowland agro-forest of Mount Palili, Caraballo Mountains, Luzon (Alviola *et al.,* 2011). According to Tan *et al.* (1998), *C. brachyotis* is widespread in Southeast Asia and common throughout the Philippines which can occupy various habitats including primary rainforest, mangrove swamps, cultivated areas, orchards and other disturbed anthropogenic areas explaining its abundance in the study sites.

Common species recorded in all sampling sites were *C. brachyotis* and an endemic species, *Haplonycteris fischeri* Lawrence, 1939 where *C. brachyotis* was the most abundant species in site 4, an undisturbed habitat, while *H. fischeri* was the most abundant in site 6, a relatively undisturbed site. The high abundance of *C. brachyotis* was consistent except for sites 5 and 6, the relatively undisturbed areas of MMPL, which were dominated by *H. fischeri.* According to Csorba *et al.* (2008a), *C. brachyotis* is commonly found in rural and urban landscapes and in forested areas which could be the reason for the presence of this species in disturbed sites of MMPL while *H. fischeri,* an endemic species in the Philippines is common, and widespread at higher elevations where threats to the species are minimal (Ong *et al.,* 2008a). Sanchez-Cordero (2008) described endemic species as restricted to high-elevation habitats but can also be present in mixed agricultural habitats and second-growth forest which is the case of *H. fischeri.* Heaney *et al.* (2005) also observed widespread distribution of bat species in

disturbed habitats; however endemic species are rarely found far from primary rain forest. Moreover, Rickart *et al.* (2007) stated that native species have variable tolerance for disturbance; many can persist in moderately disturbed habitat and can re-colonize areas that have been severely disturbed.

Table 1. Species composition, status of distribution and conservation, and abundance of bats in Mt. Matutum Protected Landscape.

Species	Conservation Status	Distribution	Disturbed Sites			Undisturbed Sites			Total
			Site 1 Lowland Dipterocarp Forest 500-800 masl Linan, Tupi	Site 2 Montane Forest 1,323 -1,370 masl Glandang, Tupi	Site 3 Mossy Forest 1600 -1,714 masl Glandang, Tupi	Site 4 Lowland Dipterocarp Forest 987-997 masl Kawit, Polomolok	Site 5 Montane Forest 1325 -1339 masl Kawit, Polomolok	Site 6 Mossy Forest 1612 -1719 masl Kawit, Polomolok	
Family Hipposideridae									
Hipposideros cervinus (Fawn-collored Leaf Nosed Bat)	LC	NE	3(8.33)	0	0	0	0	0	3 (1.02)
Family Pteropodidae									
Cynopterus brachyotis (Lesser Dog-faced Fruit Bat)	LC	NE	14(39)	14(32.6)	20(34)	62(65)	1(17)	13(24)	124 (42.3)
Dyacopterus spadiceus (Dayak Fruit Bat)	NT	NE	0	0	0	15(16)	0	0	15 (5.12)
Haplonycteris fischeri (Philippine Pygmy Fruit Bat)	LC	E	1(2.7)	1(2.3)	17(29)	3(3.2)	2(33.3)	27(50)	51 (17.4)
Harpyionycteris whiteheadi (Harpy Fruit Bat)	LC	E	0	0	1(1.7)	0	0	2(3.7)	3(1)
Macroglossus minimus (Dagger-toothed Long-nosed Bat)	LC	NE	2(5.6)	6(14)	7(12)	1(1.05)	0	3(5.6)	19 (6.5)
Megaerops wetmorei (White-collared Fruit Bat)	V	NE	14(38.9)	11(26)	0	8(8.4)	0	3(5.6)	36 (12.3)
Ptenochirus jagori (Greater Musky Fruit Bat)	LC	E	0	1(2.3)	1(1.7)	1(1.05)	0	0	3(1.02)
Ptenochirus minor (Lesser Musky Fruit Bat)	LC	E	1(2.8)	0	13(22)	1(1.05)	0	0	15 (5.12)
Family Rhinolophidae									
Rhinolophus inops (Philippine Forest Horseshoe Bat)	LC	E	0	6(14)	0	1 (1.05)	3(50)	6(11)	16 (5.5)
Rhinolophus philippinensis (Large-eared Horseshoe Bat)	LC	NE	0	0	0	1(1.05)	0	0	1(0.34)
Rhinolophus subrufus (Small Rufous Horseshoe Bat)	DD	E	0	4(9.3)	0	0	0	0	4(1.4)
Rhinolophus virgo (Yellow faced Horseshoe Bat)	LC	E	0	0	0	1(1.05)	0	0	1(0.34)
Family Vespertilionidae									
Murina sp.	-	-	1(2.8)	0	0	0	0	0	1(1.4)
Scotophilus kuhlii (Lesser Asiatic Yellow Bat)	LC	NE	0	0	0	1(1.05)	0	0	1(1.4)
Total number of species			7	7	6	11	3	6	15
Total number of individuals			36	43	59	95	6	54	293 (100)
Total number of endemic species			2	4	4	5	2	3	7
Total net nights			55	45	45	64	52	40	301

Legend: ( ) relative abundance, DD – data deficient, LC – least concern, NT – near threatened, V – vulnerable, NE – non-endemic, E - Philippine endemic

Among the endemic species, *Rhinolophus subrufus* consisting of four individuals was only found in site 2, a disturbed montane forest. This species was also reported in the provinces of Camiguin, Catanduanes, Abra, Camarines Sur, Isabela, Laguna, Pampanga, Rizal, Sorsogon, Davao del Sur, South Cotabato and Mindoro in the Philippines (Heaney, 1991). However, its habitats are poorly known. This species was

recorded near sea level, in over 1000 m, and in caves (Warguez *et al.,* 2013). *Rhinolophus virgo,* an endemic species was only found in site 4, an undisturbed lowland dipterocarp forest which concurs with the observation of Ong *et al.,* (2008b) that *R. virgo* is a lowland species that occurs in a number of protected areas.

According to Mildenstein *et al.* (2005), bats prefer undisturbed forest types and Rickart *et al.* (2007) reported that native mammal species are most diverse and abundant in habitats that are relatively undisturbed, but many occur in disturbed forest and some persist in second-growth which in the case of sampling site 4, an undisturbed lowland dipterocarp forest which had the most number of endemic species. All of the sampling sites surveyed had endemic species indicating the need for continued protection of MMPL.

Table 2. Bat diversity indices across elevation and disturbance gradients in MMPL.

	Disturbed Sites			Undisturbed Sites		
	Site 1 Lowland dipterocarp	Site 2 Montane	Site 3 Mossy	Site 4 Lowland dipterocarp	Site 5 Montane	Site 6 Mossy
Species richness	7	7	6	11	3	6
Number of individuals	36	43	59	95	6	54
Shannon diversity	0.89953	0.89953	0.74455	1.6742	1.118	0.991
Evenness	0.462	0.345	0.421	0.698	0.991	0.553

The only vulnerable species documented in the sampling sites is the White-collared fruit bat, *Megaerops wetmorei* which was encountered in the four sampling sites (sites 1, 2, 4, and 6) and appears to be abundant in MMPL indicating the importance of MMPL as an important habitat for the conservation of bat species. According to Heaney *et al.* (1998), *M. wetmorei* is known only from primary and lightly disturbed lowland forest from 800 to 1,200 masl and probably absent from montane and mossy forests above 1,500 masl. However, in this study this species was also found in site 6 at 1612 -1719 masl indicating that this species can also occur in elevation above 1500. Rosell-Ambal *et al.* (2008) reported that *M. wetmorei* has been recorded only on Mindanao Island (Agusan del Norte, Bukidnon, Davao del Sur, Davao Oriental, Lanao del Norte, Lanao del Sur, Misamis Oriental, South Cotabato, and Zamboanga del Sur provinces) and occurs in a number of protected areas throughout its range. Moreover, the near threatened species *Dyacopterus spadiceus* (Dayak Fruit Bat**)** was only found in site 4, a lowland area near riverine system. Csorba *et al.* (2008b) documented *D. spadiceus* in lowland are near stream.

Table 3. Comparison between species in disturbed and undisturbed sites.

Test	Kruskal-Wallis Test		Interpretation
	H (chi 2)	P (same)	
Species Diversity	3.971	0.046	Significant difference between samples
Evenness	3.857	0.050	No significant difference between samples

Species Similarity

Fig. 2 shows Site 6 having high species similarity with other sites except site 5. The maximum species similarity was observed between sites 6 (mossy, undisturbed) and2 (mid-montane, disturbed) having a value of >72% which mean that there is a higher number of species common or similar in the two sites. An average similarity indices for sites 3 and 6, and 4

and 6 and minimum similarity between sites 5 and 1 were detected. Difference in tree species composition and vegetation community structure could be pointed as reasons for this spatial distribution of species.

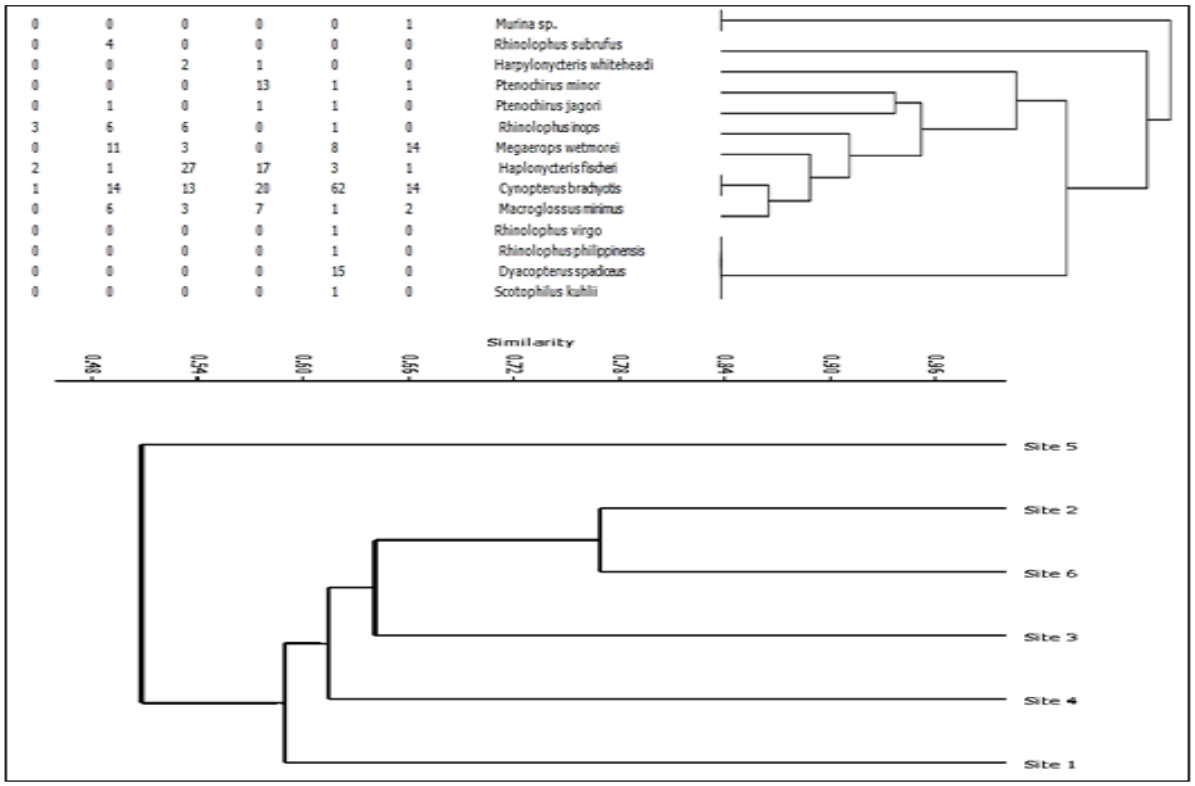

Fig. 2. Species similarity across elevation and disturbance gradients in MMPL.

Species Diversity

Sites 4 and 5 which are relatively undisturbed sites showed moderate bat diversity but other sites had low diversity (Table 2). Uneven distribution of species was observed in the disturbed sites while a more or less even distribution was observed in the undisturbed sites. Disturbance (Limberger and Wickham, 2012) and the availability of food in the area could affect evenness of species (Ligate *et al.,* 2014). Site 4, an undisturbed site had the highest species richness including highest number of individual capture for *Cynopterus brachyotis* is at 65% relative abundance. The complex structure of the forest vegetation in site 4 which is a lowland mixed agricultural and secondary forest with presence of fruit trees and understory plant (*Impatiens platypetala)*, dominant trees (*Trema orientalis*, *Piper arborescens*) and emergent tree (*Pterocymbium tinctorium*) contributed to the abundance of food sources that support the higher population and richness of bat species. According to Tan *et al.,* (2000), all members of the Family Pteropodidae are phytophagous taking fruits, floral resources or leaves which are abundant in Site 4, while the Family Rhinolopidae are insectivorous bats (Simmons and Conway, 1997) that primarily eat insects which abounds in the vegetation type in site 4. Moreover, bats also feed on leaves for the sustenance of their carbohydrate and water requirements for their maintenance and reproduction (Elangovan *et al.,* 2001). Species richness of bats can show congruence with species richness of endemic tree species at moderate spatial scale level of forests. High species richness of bats is observed in tropical forests with high species richness of endemic tree species although this positive relationship is found to be weakly correlated (Van Weerd and Udo de Haes, 2010). The low diversity in all the other sites appears to be due to disturbance. According to Hobbs and Huenneke (1992), disturbance affects structural and

habitat diversity as well as the overall species diversity in the area.

Members of the genus Pteropodidae, whose preferences are fruits, pollen and flower nectars (Hill and Smith, 1984), were observed to dominate the bat composition particularly small pteropodids in Mount Matutum Protected Landscape. The small pteropodids have distinct diet preferring dull fruits while large pteropodids are relatively generalists often overlapping with birds (Hodgkison *et al.,* 2003). The presence of fruit bearing trees adjacent to and within the MMPL forest may explain this observation. Fruits with dull and green-yellow or dull red brown preferred by small pteropodid (Utzurrum, 1995; Hodgkison *et al.,* 2003) abound in the area.

The diversity of species between disturbed and undisturbed sites showed significant difference as shown in Table 3 with undisturbed sites appearing to be more diverse. There was, however, no significant difference on evenness between species in disturbed and undisturbed sites.

Threats to Mt. Matutum Protected Landscape

Threats to biodiversity observed in MMPL are the conversion of forest to farmland and hunting of wildlife. Logging of trees in the area is not uncommon and clearing of lands to expand farming areas are practiced by a few local people. Green (2013) noted that conversion of forest to farmland is one of the most common causes of habitat loss in the wild. Rapid increase in the human population that resulted to increase demand for land area and other natural resources contributes greatly to the declining populations of different species (Pimentel *et al.,* 2007). This alteration of natural habitat of organisms including climate change has been linked to a global decline in vertebrate population (Forister *et al.,* 2010).

Hunting is believed to threaten the survival of many important wildlife species (Gubbi and Linkie, 2012). However, local people in the MMPL are used to hunting wildlife. Local accounts revealed that bats and other non-volant mammals are hunted as source of food and few species are sold in the market as traditional medicine. This anthropogenic activity is one of the contributing reasons for the rapid decline of wildlife in the wild (Conover, 2001). In the Old World tropics like the Philippines, Mickleburgh *et al.* (2009) reported a high extent of bat hunting for bushmeat particularly of genus *Pteropus*. The continuous expansion of human settlements and agricultural areas within the protected area may drastically change its habitat characteristic (Ogutu *et al.,* 2012) as well as endangering the future life of wildlife species. This poses a threat to the diversity of bats. Bats provide significant ecological services to the environment and need to be protected.

Conclusion

Mt. Matutum Protected Landscape has moderate diversity of bats in the relatively undisturbed sites but low diversity in the disturbed sites indicating the impact of habitat change in the area. Undisturbed sites support higher number of bat species than disturbed sites. Conversion of forest to farmland and hunting of wildlife were seen as threat to bat fauna indicating the need for strengthened protection of the Mount Matutum Protected Landscape.

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