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Species diversity of fruit bats in Bega Watershed, Prosperidad, Agusan del sur, Philippines

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Abstract

Bats are known to be effective pollinators and seed dispersers that aid in shaping forest ecosystems. This study was conducted using the mist netting method to determine species diversity of fruit bats in three sampling sites in Bega Watershed, Barangay Mabuhay, Prosperidad, Agusan del Sur, Philippines. One hundred eighteen individuals comprising eight bat species were documented. Four species are endemic to the country of which one species, *Ptenochirus minor*, is restricted to the Mindanao Faunal Region. *Megaerops wetmorei* was the only species recorded with vulnerable status but was present in all sampling sites. Seriation analysis using Paleontological Statistics Software showed that there is an increasing trend of species richness from sampling sites 1 to 3. Moderate diversity was observed for the whole area (H'=2.004) and site 3 was the most diverse among all sites. Cluster analysis showed that sites 2 and 3 have more similar species composition. The presence of endemic and vulnerable species suggests that Bega watershed is an area of conservation importance.

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Introduction

The Philippines is geographically part of Southeast Asia and is the second largest archipelago in the world with over 7, 100 distinct islands (Ambal *et al*., 2012). It is recognized by Mittermeier *et al*., (1999) as a mega-diverse country with more than 20, 000 endemic species together with 17 other countries that hold two-thirds of the earth's biodiversity. For the terrestrial mammalian fauna alone, 206 species exist of which 117 are endemic (Heaney *et al*., 2010). A large proportion of this is comprised of bats which is the sole representative of Order Chiroptera (Mould, 2012). According to Heaney *et al*., (2010) there are 78 bat species in the Philippines including 25 fruit bats and 53 insect bats. Of these, approximately 35.5% are endemic (Heaney *et al*., 2000). In Mindanao region which is the second largest island in the archipelago, 53 bat species have been recorded by Ingle *et al.,* (1999) where *Alionycteris paucidentata* (Kock. 1969), *Ptenochirus minor* (Yoshiyuki, 1979) and *Hipposideros coronatus* (Peters, 1871) are recognized to be Mindanao restricted. Heaney *et al.,* (2006) recorded 32 bat species in Mt. Kitanglad Nature Park in Mindanao. Lobite *et al*., (2013) recorded eight bat species along the Cagayan River Zone representing 10% of the Philippine bat fauna. Achondo *et al.,* (2014) documented eight fruit bats with three endemic species in two conservation areas in North Cotabato. In the survey conducted by Nuñeza and Galorio (2014) in cave bats of Siargao island, eight cave bat species were recorded with low level of endemism (25%). Mohagan *et al.,* (2015) recorded 13 volant mammals in four long term ecological research sites situated in Mounts Apo, Kitanglad, Hamiguitan and Malindang where two fruit bat species, *Macroglossus minimus* (É. Geoffroy, 1810) and *Haplonycteris fischeri* (Lawrence, 1939) were the species present in all sites. Elevation affects the species richness, diversity and abundance of bats (Heaney *et al.,* 2006; Maryanto and Yani, 2003; Hodgkison *et al.,* 2004).

The abundance and diversity of bats made them occupy different sets of habitats ranging from caves (Kalko *et al.,* 1999), forests (O'Malley *et al*., 2006), and riparian zones including rivers (Kunz *et al*., 2003; Lobite *et al*., 2013) that provide them with food and water and are considered important for their hunting activities. Bats are considered as important components of the forest and other ecosystems as they perform indispensable services that have enormous ecological and economic importance (Kingston, 2008). Seed dispersal by fruit bats plays immense role in the maintenance of forest ecosystems. The plant-visiting megabats of family Pteropodidae disperses seed to at least 300 plant species under 200 genera due to their mobility (Fujita and Tuttle, 1991). The pollination experiment of Bumrungsri *et al*., (2007) confirmed that the nectarivorous bats *Eonycteris spelaea* (Dobson, 1871) are effective pollinators of petai (*Parkia speciosa* Hassk. and *P. timoriana* Merr) and durian (*Durio zibethinus*). The guano produced by bats as waste material is a known source of organic fertilizer (Kingston, 2010) and source of nutrients for a wide and unique communities of organisms (Pellegrini and Ferreira, 2012). Because of the ubiquity of bats in the forested areas of the tropics (Mickelburgh *et al.,* 2002), Medellin *et al.,* (2000) proposed that they are important indicators for evaluating sensitivity to ecological annihilation.

Bat surveys are used for conservation planning on the assumption that the protection of bats will protect key habitats for many other taxa (Francis *et al.,* 2010). However, given the numerous vital services provided by bats, nearly half of the species are of conservation concern and as many as 40% of them are anticipated to be extinct by the end of this century (Kingston, 2008). Disturbance and environmental changes (Warguez *et al.,* 2013) coupled with overhunting (Brooke and Wiles, 2009; Racey and Entwisle, 2003), mining of guano (Sedlock and Ingle, 2010), deforestation (Racey and Fleming, 2009) and mining of swiflet nets (Rahman *et al.,* 2011) can hugely affect bat population.

Researchers in the Philippines have been investigating bat ecology in order to assess its diversity and conservation status however it is still considered as one of the poorly known mammalian order (Ingle and Heaney, 1992). New species are being discovered such as the new species of stripe-faced fruit bat, *Styloctenium,* from Mindoro Island (Esselstyn, 2007) and the new species of flying fox of genus *Desmalopex* in the same island (Esselstyn *et al.,* 2008). Heaney *et al.* (2012) reported the first records of *Nyctalus plancyi* (Gerbe, 1880) in Central Cordillera of North Luzon and three new specimens of the poorly known species of *Falsistrellus petersi* (Meyer, 1899). Along with the continuing discovery of new bat species are rediscoveries of species feared to have become extinct (Posa *et al.,* 2008). In 2001, three species of bare-backed fruit bat (*Dobsonia chapmani,* Rabor, 1952) which were believed to be extinct in 1964 were netted at Carmen, Cebu (Paguntalan *et al.,* 2004). This was again followed by the capture of another five *Dobsonia chapmani* by Alcala *et al.*, (2004) in karst habitat of Negros Island two years later. These exciting rediscoveries only highlight the value of basic diversity survey.

While there are numerous studies conducted in other parts of the country, insufficient information still exists on the diversity of fruit bats (Family Pteropodidae) in other areas of Mindanao particularly in the Municipality of Prosperidad, Agusan del Sur where no study has been done. This survey is considered as the first documentation of the diversity of fruit eating bats in Bega Watershed. This is important in establishing baseline information on bat diversity in the area. The objectives of this study were to determine species richness, endemicity, conservation status, relative abundance, biodiversity indices of the bat species present in Bega Falls area situated in Barangay Mabuhay, Prosperidad, Agusan del Sur Philippines. Threats to the bat species were also identified.

Materials and methods

Description of the Study Area

The Municipality of Prosperidad is the capital of the Province of Agusan del Sur, Philippines (Fig. 1). It lies within 08°36’ North and 125°55’East, on the northern part of the province. It is composed of 32 barangays and has a total area of 505.15 sq. km. The sampling of bat species was conducted in Bega Watershed located in Purok 5, 5.2km from Barangay Mabuhay, Prosperidad, Agusan del Sur located at 8°43.81’’ North and 125°59.74’’ East. Fig. 1 shows the map of the Philippines and Prosperidad, Agusan del Sur, the study area.

Sampling Sites

Sampling site 1 was near the Bega Falls where three net lines were established. Net site 1 had coordinates of 8°69’95.6”N and 125°97’40.9”E, 225 meters above sea level (masl). Net site 2 was in 8°69’76.2”N and 125°97’39.1”E, 250 masl while net site 3 was in 8°69’96.0”N and 125°97’51.9”E, 288 masl. Sampling site 1 has a secondary type vegetation and a mountainous slope of 20-30°. The height of emergent tree was approximately 20m with diameter at breast height (DBH) of 0.557m. Canopy tree was estimated to be 12m high with 0.312m DBH. It was dominated by *Musa* sp., *Ficus* sp., *Pandanus* sp., *Artocarpus odoratissimus* (“marang”), *Sandoricum koetjape* (“santol”), *Colocasia* sp. (“gabi”), and *Hevea brasiliensis* (rubber). The ground with loam soil was covered with ground orchids, *Pepersi drynaria* (ferns) and grasses such as *Paspalum conjugatum* and *Mimosa pudica*. Exposed rocks were abundant near the slow moving stream and waterfalls. Fallen logs were also observed in the area. A road for vehicles was 1.5km away from the sampling site.

Sampling site 2 near the Enchanted Falls has secondary type vegetation with slope that was flat to undulating. Four net sites were established in selected areas. Net site 1 was situated at 8°70’20.1”N and 125°98’28.9”E, 291 masl. Net site 2 was in 8°70’19.9”N and 125°98’29.2”E, 281 masl. Net site 3 was in 8°70’19.0”N and 125° 98’31.6”E, 294 masl while net site 4 was in 8°70'22.3"N and 125°98'34.9"E, 297 masl. Emergent trees that were dominated by "Tugop" were approximately 35m tall and have DBH of 0.668. Canopy trees estimated to be 12m high with 0.299mDBH were mostly of the genus *Shorea* (Lauan). Fruit-bearing trees were also observed in the area such as *Canarium* sp. and *Clausena* sp. Canopy epiphytes were represented by ferns and mosses. Liana vines were the common canopy vines present in the area. Understory plants such as figs of the family Moraceae, *Cyathea* sp., *Alocasia* sp., *Pepersi drynaria, Justicia* sp. and various grasses were observed to grow in the clay soil type. *Ficus* sp. while *Musa* sp. was rare. Exposed rocks were abundant and very few fallen logs were seen. Swidden farming was observed 25 meters from the site.

Fig. 1. Map of the Philippines (A) (http://en.wikipedia.org, 2015) showing the sampling area, Prosperidad, Agusan del Sur (B) (http://en.wikipedia.org, 2014).

Sampling site 3 was established 200m away from Tiger falls. The site has closed canopy secondary vegetation with flat to undulating slope. Emergent tree composed of *Shorea* were approximately 25-30m high and have DBH of 0.547m while canopy trees dominated by 'Macaranga' were estimated to be 15m high with DBH of 0.891m.Four net sites were established. Net site 1 was situated at 8°70'41.8"N and 125°98'38.2"E, 316 masl. Net site 2 was in 8°70'45.1"N and 125°98'30.7"E, 312 masl. Net site 3 was in 8°70'42.7"N and 125°98'29.1"E, 320 masl, and net site 4 was in 8°70'41.7"N and 125°98'30.1"E, 312 masl. Canopy trees are mainly *Shorea*. Ferns, mosses, orchids, rattan and lianas are the canopy epiphytes and vines observed in the area. There was moderate abundance of understory plants dominated mainly by plants belonging to *Cyathea* sp., *Ficus* sp., *Pandanus* sp. and *Freycinetia* sp. Ground story plants include grasses and ferns. The type of soil is loam with 0.5 in leaf litter. No anthropogenic activities were observed near the sampling site.

Sampling, Processing and Identification of Bat Samples

The field work was done on May 8-15, 2014 in three sites with varying vegetation and elevations ranging from 225-320 masl for a total of 118 net nights. Fifteen mist nets measuring 12 meters in length and four meters in width having four shelves were used singly or in series to maximize capture efficiency. Canopy nets were set on possible bat flyways and feeding sites while sub-canopy nets were positioned along ridges or by the stream (Heaney *et al.*, 1989) at heights ranging from 0-10 meters above the ground. The nets were left open to capture bats and were monitored every 30 min interval at dusk between 1800-2000 hours at which bats are at the peak of their activities (Mohagan *et al.*, 2015) and at dawn between 400-500 hours. Captured bat was removed from the net by first determining which side it entered then carefully removing one wing first, then the feet and lastly the tail if present (Hoffman *et al.*, 2010). This was done carefully to avoid causing much stress or damage to the bat body part that may cause unwanted mortality.

Each bat sample was placed in separate cloth bags and was examined at the camp site. The bats were sexed, aged and identified using Ingle and Heaney (1992). Sex was determined by examination of external genitalia such that males possess a striking penis while adult females have more noticeable or swollen axillary nipple on the upper chest than males. Age of the bats was determined by the degree of ossification of the joints in the digits of the wing (Anthony, 1988). This was done by stretching one wing of the bat before a flashlight in which a juvenile bat has partly translucent bands representing the cartilaginous discs where growth takes place while adult bats have opaque joints suggesting fully ossified bones. Reproductive status was also identified to determine if female bats were pregnant or not. De-furred nipples were taken as a sign of lactation

Body weight was taken using a Pesola spring balance while external measurements such as forearm length, hind foot length, ear length, tail length, and total length were recorded with the aid of a caliper (O'malley *et al.*, 2006). All captured bats were marked on the wings to avoid recounting in cases of recaptures. Sucrose solution was given to the bats to re-energize them after the stress caused by their entrapment and were subsequently released after all the morphometric data and photos were taken. Identification was based on Ingle and Heaney (1992)

Conservation status as well as distribution status of captured bats was checked using the online red list of International Union of Conservation Network (IUCN, 2014).

Data Analysis

Species richness, endemicity, and relative abundance were computed. Seriation analysis, diversity indices, cluster analysis and Principal Component Analysis (PCA) were done using Paleontological Statistics Software (PAST).

Results and discussion

Species Richness, Endemism, Abundance, and Conservation Status

Eight species of fruit bats with a total of 118 individuals composing 10% of the total bat species found in the country were captured from the three sampling sites in Bega Watershed, Barangay Mabuhay, Prosperidad, Agusan del Sur (Table 1). These Pteropodids are known to play significant roles in the maintenance of forest diversity by dispersing seeds, pollinating plants, as well as introducing novel plants in previously disturbed areas (Kelm *et al.*, 2008; Fleming *et al.*, 2009; Kunz *et al.*, 2011). The highest number of species (S=8) was recorded in sampling site 3 near the tiger falls while site 1 had the least number of species (S=5). Seriation analysis through PAST presents a graphical representation of the chiropteran species richness in relation to the sampling sites and elevation (Fig. 2). Results showed that as elevation increases there was an increasing trend of species richness from sites 1 to 3 which is in agreement with McCain (2007). The residential areas near site 1 may also have an effect on species richness in the site. According to the study of Threlfall *et al.*, (2012) in Australia, bat activity and richness are higher in low density and semi-natural areas than in high density residential areas. Strong human pressure lowers species richness (Odum and Barrett, 2006).

Table 1. Species list, endemic species, distribution status, conservation status, and relative abundance, of fruit bats in Bega Watershed, Prosperidad, Agusandel Sur.

Scientific Name (Common name)	Conservation Status	*Sampling Sites			Total
		1 (225-288 masl)	2 (281-297 masl)	3 (312-320 masl)	
Family Pteropodidae					
Cynopterus brachyotis (Lesser Dog-Faced Fruit Bat)	LC	6 (24)	13 (26)	5 (11.63)	24 (20.34)
PE *Haplonycteris fischeri* (Fischer's Pygmy Fruit Bat)	LC	3 (12)	5 (10)	1 (2.33)	9 (7.93)
PE *Harpyionycteris whiteheadi* (Harpy Fruit Bat)	LC	0	0	8 (18.6)	8 (6.79)
Macroglossus minimus (Lesser Long-Tongued Fruit Bat)	LC	9 (36)	5 (10)	9(20.93)	23 (19.49)
Megaerops wetmorei (White-Collared Fruit Bat)	VUL	4 (16)	8 (16)	2 (4.65)	14 (11.86)
PE *Ptenochirus jagori* (Greater Musky Fruit Bat)	LC	0	3 (6)	8 (18.6)	11 (9.32)
MFRE *Ptenochirus minor* (Greater Musky Fruit Bat)	LC	3 (12)	10 (20)	5 (11.63)	18 (15.25)
Rousettus amplexicaudatus (Geoffroy'sRousette)	LC	0	6(12)	5 (11.63)	11 (9.32)
Total number of individuals		25	50	43	118
Total number of Species		5	7	8	8
Total RA (%)		21.19%	42. 37%	36.44%	100%
Total number of endemic		2*(1)	3*(1)	4*(1)	5*(1)
% endemic		25	37.5	50	50
Total threatened		1	1	1	1
Total Net nights		45	30	45	115

Legend: PE - Philippine Endemic; MFRE- Mindanao Faunal Region Endemic, ()-relative abundance of species, MFE*() – Mindanao faunal region endemic, LC- Least concern, VUL- Vulnerable.

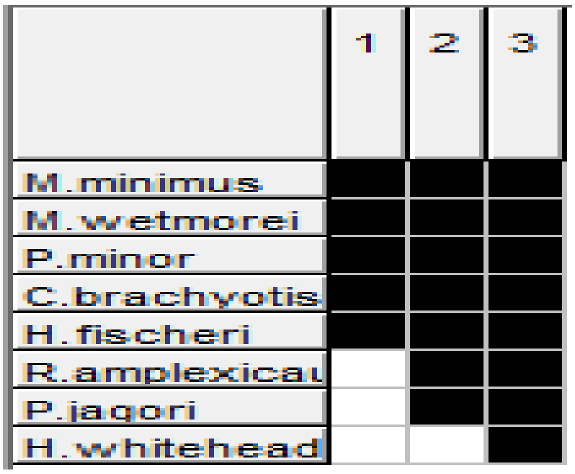

Fig. 2. Seriation analysis of the bats in Bega Watershed through PAST.

Four species of the fruit bats captured are restricted to the country including the Philippine endemic *Haplonycteris fischeri* (Lawrence, 1939), *Harpyionycteris whiteheadi* (Thomas, 1896), *Ptenochirus jagori* (Peters, 1861) and the Mindanao faunal region endemic *Ptenochirus minor* (Yoshiyuki, 1979) that together constitute 50% endemicity in the area. Sampling site 3 had the highest number of endemic species documented (S=4) accounting for 50% endemism. Only *H. fischeri* and *P. minor* were the endemic species observed in site 1. This sampling site was near to anthropogenic disturbances as it can be accessed easily by tourists. According to Sewall *et* *al.,* (2003) endemic bat species are known to be sensitive to disturbances. However, disturbance brought about by tourists on the day roosts of bats, especially the endemic species, increases bat flights and alertness poses a threat to the conservation of this mammal (Cardiff *et al.,* 2012).

Seven of the captured fruit bats are categorized as least concern in the IUCN red list of species. *Megaerops wetmorei* was the only species recorded which has a status of vulnerable. The highest number of individuals captured was observed in sampling site 2. Although *M. wetmorei* is generally widespread in Southeast Asia including the Mindanao Island, its population was already observed to be declining (Heaney *et al.*, 2010). Lobite *et al.*, (2013) recorded low abundance of *M. wetmorei* in Nasipit, Agusan, del Norte. Heaney *et al.,* (2006) and Fleming and Racey (2010), observed that *M. wetmorei* mainly inhabits the lowland forest within the elevation range of 800-1200 masl. Its occurrence in all sampling sites (225-320 masl) in this study can be related to recent study of Achondo *et al.*, (2014) in which *M. wetmorei* was found in a new altitudinal record as low as 58masl. The presence of endemic and threatened species of bat in the study area highlights the importance of conservation.

Relative abundance of species per sampling site was found to be highest in site 2 (42.7%) followed by site 3 (36.44%). The nets in these sites were established in closed canopy areas however nets in site 2 were closer to a water source provided by the Enchanted Falls. According to Racey (1998) bat activity is commonly greatest in areas near sources of water that provides them with food and water. Maryanto *et al.*, (2011) also reported that abundance can be influenced greatly by food availability as well as habitat types. The least abundance in site 1 (21.19%) can be accounted to the openness of the canopy cover where the nets were established. This result concurs with the findings of Vleut *et al.*, (2012) that bat abundance can be negatively affected by the openness of canopy cover. *Cynopterus brachyotis* (Muller, 1838) was the most captured bat species accounting for 20.34% abundance followed by *Macroglossus minimus* (É. Geoffroy, 1810) at 19.49% which is known to have a strong flight capacity (Maryanto *et al.,* 2011). Both these fruit bats were present in all sampling sites. These widespread species can be observed mainly at low elevations and are very common in every type of habitat especially the disturbed ones (Heaney *et al.,* 2006; Alviola *et al.*, 2011). According to Heaney *et al.,* (2005), disturbance tolerant species tend to have wider distribution than those which are rain forest-restricted. The abundance of *C. brachyotis* and *M. minimus* can also be accounted for the presence of the plants they forage such as *Ficus* (Utzurrum, 1984) as well as *Musa* sp. that are present in all sites. The Mindanao faunal region endemic *P. minor* and the vulnerable *M. wetmorei* were also present in all sampling sites with relative abundance of 15.25% and 11.86%, respectively. Their presence can be attributed to the abundant fruiting trees they rely upon and forage in the subcanopy (Francis 1994) such as *Ficus* sp., and *Musa* sp. *P. jagori* and *Rousettus amplexicaudatus* (É. Geoffroy, 1810) have the same number of individuals captured (n=11) and so are their relative abundance at 9.32%. Both of these bat species were recorded in sites 2 and 3 only. These bats are abundant in lowland forests (Heaney *et al.*, 2010). *P. jagori* roosts in hollow trees and in shallow caves in limestone and earthen banks and is known to rely heavily on figs and *Musa* which are abundant in the two sampling sites. On the other hand the presence of *R. amplexicaudatus*, a cave dwelling bat species (Francis, 2010), in the sites can be due to the cave that can be found in the immediately neighboring Sitio Malipaga. The abundance of figs and over-ripe fruits which it primarily consumes in the area 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) during its foraging time. The Philippine endemic *H. fischeri* had an over-all relative abundance of 7.93%. This low abundance is because this bat is more common in primary forest than in secondary forest (Heaney *et al.,* 2010) where threats are minimal. It is most abundant in site 2 (RA=10%) due to the abundance of *Ficus* fruits along the stream in which it forages. The least abundant bat captured was *H. whiteheadi* (6.79%) which was found only in site 3 where no anthropogenic activity was observed. It was only recorded in canopy mist nets suggesting that this bat species is a moderately high flyer. According to Paguntalan and Jakosalem (2008), *H. whiteheadi* is a forest dweller which prefers habitats with huge trees, high zonation and less disturbance. It is also primarily forages on the fruits of viney pandans (*Freycinetia* spp.) (Rickart *et al.*, 1993) which were present with moderate abundance in site 3 only.

Fig. 3 shows the dendrogram for the cluster analysis of the chiropteran assemblage recorded in the study area. Sampling sites 2 and 3 have high similarity value and are therefore clustered together forming the first clade of the tree. This suggests that these two sites have more similar species composition (Mohagan *et al.*, 2015) than with sampling site 1 which is clearly separated as the outgroup. The result is compelling since sites 2 and 3 are very close not just in terms of the species composition but also because both have more or less closer numbers of individuals captured, endemic species, relative abundance and diversity values. A high similarity indicates that there are few species differences between sites (Diserud and Ødegaard, 2007).

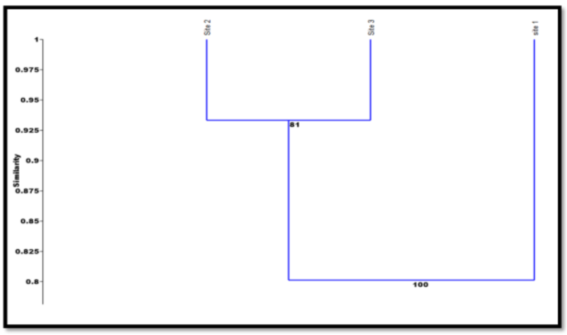

Fig. 3. Dendrogram of the similarity of species composition of bats in the three sites of Bega Watershed.

Fig. 4 shows the relationship between the distribution of sexes of the fruit bats and their reproductive status with the sampling sites which is affected by habitat quality and food supply (Speakman *et al.,* 1991). Results showed that sites 2 and 3 are associated with lactating and non-lactating adult females while male adults tend to be more distributed among the sites. Most females, especially the pregnant and lactating ones occur in habitats with abundant food as they rely on current resource intake to support costs of reproduction and for them to reconcile the conflicting demands of foraging and nursing (Henry *et al.*, 2002). Sites 2 and 3 are equipped with these resources. Males on the other hand, segregate to lessen competition with pregnant and lactating female bats and juveniles (Altringham and Senior, 2005). This behavior of male bats is believed to result to the reproductive success of the bat population (Kunz *et al.*, 1998). The highest number of captured juvenile bats was found in site 2. Flaquer *et al.,* (2008) recorded that juvenile bats are less mobile than adult bats so they prefer easily accessible habitats. Site 2 in this study was nearer to a water source than the other sites. It contained plenty of food resources for fruit bats such as figs, bananas and other fruiting trees. It can also serve as suitable roosting site due to the presence of large trees and its close canopy cover. According to Duverge *et al.*, (2000), the survival of juvenile bats largely depends on the nearby presence of feeding sites therefore knowledge on the differences in foraging sites of adult and juvenile bats is important to ensure adequate habitat protection around their roost sites (Goiti *et al.,* 2006).

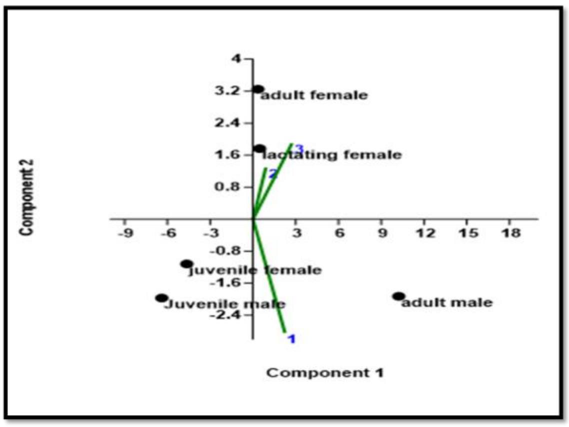

Fig. 4. Principal Component Analysis and biplot of the three sampling sites.

Biodiversity indices

The overall bat diversity was moderate with Shannon diversity index value of 2.004 (Fig. 5). Canopy mist nets were not established in sites 1 and 2 due to steep railings near the water falls and the absence of accessible branches of tall trees to place the nets. Among the three sampling sites, site 3 was the most diverse (H'=1.934). Elevation, presence of the Tiger falls nearby as source of water, different plant composition in which different species of bats may forage and varying structural vegetation that served as roosting sites were observed to have accounted for its diversity. The completely enclosed sampling area (Vleut *et al.,* 2012) as well as the microclimate in the site (Maryanto and Yani, 2003; Hodgkison *et al.,* 2004) may have also contributed to the bat diversity.

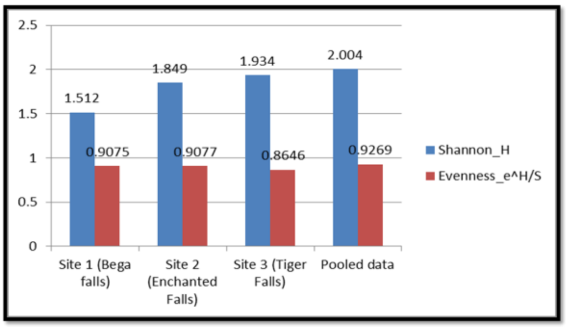

Fig. 5. Diversity and evenness of Bats in Bega Watershed, Prosperidad, Agusan del Sur.

Evenness measures how distributed the individuals among species are in an area. This value is equal to one if the species are equally abundant and no species dominates upon the other. Results showed that sites 1 and 2 have very close species evenness value (0.9075 and 0.9077) while site 3 has the least value (0. 8646). This data is to be expected because species richness is high in site 3. According to the study of Estrada-Villegas *et al.,* (2012), 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. Evenness value for the whole area was 0. 9269 which indicates a more or less even distribution of bat species and none of them dominate the other. The abundance of the food sources in the sites may have lessened competition and so even distribution is likely to be expected.

Threats to fruit bats in the area

The observed threats on the fruit bat fauna in the sampling area were the swidden farming and timber cutting. These anthropogenic activities could likely lead to the extinction of many Philippine fauna (Suarez and Sajise, 2010) including bat species by significantly reducing their habitats and roosting sites. The on-going construction of the stairs going to the Bega Falls for local tourism may have also caused disturbance to the bats since this required the workers to cut trees which may have been their roosting sites. Construction of roads can also act as a barrier to bats diverting their usual fly routes (Berthinussen and Altringham, 2012). Tourists who are there to visit the place can also pose a threat to the bats as they can disrupt bat activities (Cardiff *et al.,* 2012). Bat avoidance to visitors could reduce their feeding time. Their avoidance of prime feeding areas that are used by tourists can have a negative effect on their energy balance (Buckley, 2004). With these numbers of threats, there is a need to protect and conserve the area for the survival of the fruit bat fauna that play key roles in different ecosystems. The reduction in number or loss of fruit bats could possibly result to collapse of some communities. Therefore, fruit bat conservation should be given priority.

Conclusion

Endemism was high and *Megaerops wetmorei* was the only species recorded with vulnerable status. *Cynopterus brachyotis* was the most captured bat species which was present in all sites while *Harpyionycteris whiteheadi*, a Philippine endemic species, was the least abundant species found only in site 3. The overall diversity was moderate and species distribution was more or less even. Among the three sampling sites, sites 2 and 3 have more similar species composition. Lactating and non-lactating females were clumped in sites 2 and 3 which appear to be important conservation sites.in. The presence of endemic and threatened bat species in Bega Watershed indicates that this area must be protected and conserved.

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