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Bat diversity and its distribution in Balinsasayao Twin Lakes, a wildlife sanctuary of Negros Oriental, Philippines

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Abstract

This study surveyed the flying mammals of Balinsasayao Twin Lakes in Negros Oriental. Mist netting was used to sample bat species in the various sampling sites. A total number of 10 species of bats representing three families was recorded. The most commonly caught and abundant bat species in all sites was the common short-nosed fruit bat, *Cynopterus brachyotis*. The area is a secondary growth forest, hence, the abundance of this fruit bat. The watershed also supports endemic bat species at 40% as well as endangered species that include the *Nyctimene rabori*, Philippine tube-nosed fruit bats and *Pteropus pumilus*, little golden-mantled flying fox, a Near Threatened. Our results suggest that the forest supports a variety of bat species. However, efforts to protect and conserve the last remaining intact habitats should be done to protect these bat species.

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Introduction

Of the major faunal groups in tropical ecosystems, members of the order Chiroptera or known as bats are of particular importance in Neotropical rainforests because they often comprise about 40-50% of all mammal species, greatly influencing the species richness and diversity of mammals in these ecosystems (Fleming, 1988). Bats are one of the most fascinating mammals in the world. Generally, bats undertake a range of important ecological functions in the tropical rain forest since they are responsible for balancing the ecosystem. Through the acquisition of food, in the form of plant and animal matter, bats participate in the recycling of nutrients and energy in the ecosystem (Fleming, 1982, 1988). Furthermore, a significant number of bat species consume nectar and great quantities of fruits (Bonaccorso and Gush, 1987). These bats are known as great pollinators of many night-blooming flowers, dispersers of seeds that are economically important and agents for a broad spectrum of plants and rainforest regeneration (Heithaus, 1982; Fleming, 1988).

It has also been suggested that insectivorous bats may regulate the populations of some invertebrates in tropical ecosystems (McNab, 1982; Kunz and Pierson, 1994). In many agroecosystems, insectivorous bats are voracious predators of economically important crop pests (McCracken GF et al., 2012).

Despite the importance of bats and one of the most speciose mammalian order, their populations have experienced a marked decline in 80% of species (Phelps et al. 2018). Several species have become extinct and other species considered abundant have experienced declines (Kunz and Pierson, 1994). The declining population of bats is due to extensive deforestation and exploitation of animals for food (Pierson and Rainey, 1992). Few available studies indicate that, in spite of their mobility and slow demographic turn-over, Neotropical bats seem to be sensitive to loss and fragmentation of their natural habitat, locally undergoing decreases in species diversity and size of populations (Brosset et al., 1996; Schulze et al., 2000).

In the Philippines, bat fauna is very diverse, with 25 megachiropteran and 48 microchiropteran species (Heaney and Regalado 1998). Of these, approximately 40% are endemic (Heaney 1986). However, the megachiropteran fauna Biodiversity and Conservation (2006) in the country is also highly threatened at approximately 50% as a result of large-scale deforestation and hunting (Mickleburgh et al. 1992; Mendoza and Mallari 1997). Consequently, island habitats in the Philippines and elsewhere have been identified as particularly important for bats and a priority for conservation efforts on a global scale (Mickleburgh et al. 2002).

Negros Island in the Philippines is one of the areas need to do urgent survey as mentioned by Mickleburgh et al. (1992) since it was ranked eighth highest in the world for megachiropteran diversity and was listed sixteenth globally for requiring the establishment of protected areas for world fruit bat conservation. However, the lack of basic survey information inhibits conservation efforts (Oliver and Heaney 1996; Heaney and Regalado 1998) and there are concerns that several species may now be threatened and possibly extinct (Ingle and Heaney 1992). O'Malley et al., (2006) mentioned that Heaney and Heideman (1987) reported that it has not been possible to estimate the number of species of bats in the Philippines that are extinct or endangered because of a lack of basic surveying information, and Negros remains a priority area for faunal surveys.

Research interest and knowledge of bats in the Philippines has been steadily increasing (Sedlock 2001) but with limited focus on the Negros–Panay Faunal Region. Little work has focused on diversity and distributions of bat species in the island. There is a clear need to survey areas of remaining habitat (forests and caves) that may still support significant bat populations, endemic or otherwise, and thus assess their conservation importance.

The Balinsasayao twin Lakes is a watershed and designated as a wildlife sanctuary that appears to be an ideal site for this study. The area has a secondary

growth forest and has become established as an important site for research particularly in terrestrial ecology in Southeast Asia (Alcala and Brown, 1969). However, fraction of the forest is being cleared for subsistence farming and this fragmentation is a consequence of intense human pressure experienced in the tropics (Whitmore, 1997) that might subject to factors such as leading to species loss or restriction of population size (Turner and Corlett, 1996).

In spite of the important role played by bats in tropical ecosystems, little is known about how they are affected by habitat fragmentation (Bernard and Fenton, 2003).

Faunal studies, such as those on bats are important for a better understanding of forest management, implementation of the rules and regulations for conservation measures, and most importantly, for the awareness of local people within the vicinity of Balinsasayao Twin Lakes. Thus, the study was conducted determine the diversity and distribution of bats in Balinsasayao twin Lakes, Negros Oriental, Philippines.

Materials and methods

Study Site

The Balinsasayao Twin Lakes (Figure 1) is on the island of Negros situated in the southern mountains. The area and its 302 ha watershed (Heideman and Erickson, 1987) is located in the municipality of Sibulan, Negros Oriental with geographic coordinates of 9°21′631″N and 123°10′768 ″E. The Southestern mountain range of Negros Island is Cuernos de Negros that rises up to 1,800 meters (6,600 feet) above sea level.

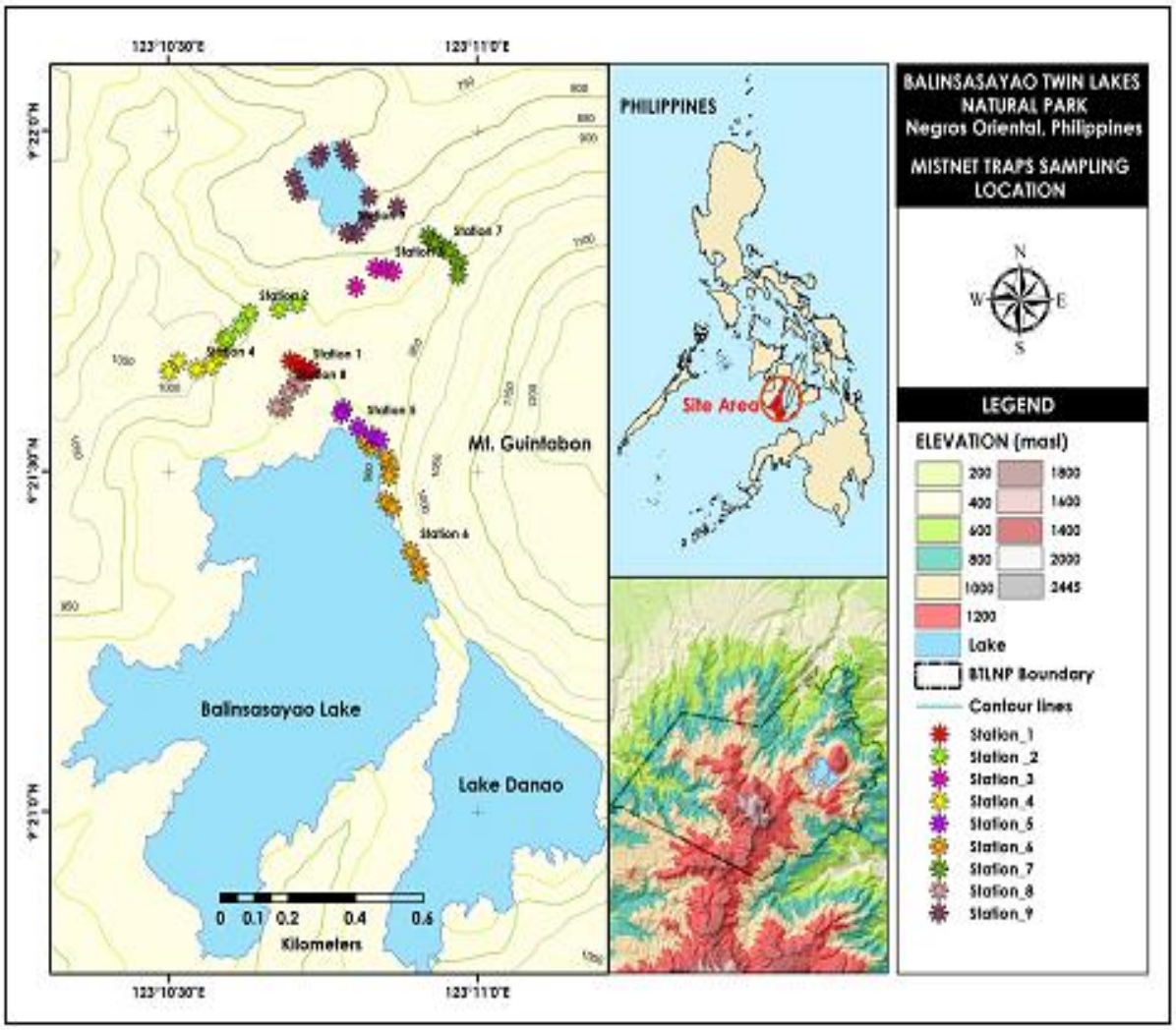

Fig. 1. Topographic map of Balinsasayao Twin Lakes with the established sampling sites.

The Twin lakes Balinsasayao has classified with some patches of secondary growth in recently cleared areas and currently dense old growth forest still surrounds the mountain peak and lakes.

At the time of the study, nine sampling sites were selectively established in terms of vegetation and elevation having several mist nets per station.

Field Survey

The research was conducted between 23 April to 08 May 2019. A total of 20 mist nets with length of 6 meters were used to sample bats. Selection of the net locations were done by ocular inspection, taking into consideration the presence of fruit trees, existence of water system such as creeks and canals that are known to be the foraging and roosting sites of bats.

Checking was done in the early evening since insect-eating bats are active at this time and every half hour thereafter from 18:00 h and continuously until at least 22:00 h and then checked again in the early morning, so as to prevent the bats from stress when being held too long in the nets.

One net-night was equivalent to one 6-m net open from dusk to early the next morning (Sedlock et al., 2008). Bats were carefully removed from the net and placed in separate cloth bags.

A species accumulation curve was the basis for determining the sufficiency of sampling efforts. When the species accumulation curve plateaus it indicates that most species have been recorded and additional sampling efforts will not yield new records of bats.

Measurement and Identification of each Sample

Captured bats were identified up to species level using the key to the bats of the Philippine (Ingle and Heaney, 1992). The sex, age, reproductive condition and biometrics such as length of forearm (FA), hind foot (HF), ear (E), tail vent (TV), and total length (T) were taken. Bat species identified and examined were marked using indelible ink on their wing membranes, after which they were released back to the forest.

Data Processing and Analysis

The data was calculated for species diversity and it was done per sampling station using the formula of Magurran (2004).

$H' = \sum p_i \ln p_i$

Where:

H' – Shannon diversity index

p_i – the proportion of individuals found in ith species (ni/N – normal estimator)

ln – normal log of data

All data were tested for normality and heterogeneity using PROC Univariate of Statistical Package for Social Science (SPSS) version 7.0. Least square differences (LSD) was carried out to compare means of independent variables with significant variations at $p \leq 0.05$.

Results and discussion

Species account

Mist netting resulted a total of 10 species of bats in three families (Table 1). Eight fruit bat species (Suborder Megachiroptera) and two insect bat species (Suborder Microchiroptera) were identified (Figure 2). Of the 37 bat species presently known in Negros (Heaney *et al.* 2010), 27% were recorded in Balinsasayao Twin Lakes. Of these, 13 fruit bat species that are known to be recorded in the island, eight species (77%) was recorded during the sampling period.

The results showed a good percentage of fruit bats present in the sampling area as compared to the Negros Island record. Only very few insect bat species were caught having only two (8%) of 24 species in the island. Only mist nets were employed that could perhaps be the reason of the low catch of insects since they could easily detect it using their echolocation ability, also the area has no caves observed that most of the insect bats believed to thrive. The site is a secondary forest with a relatively small area as compared to the entire island of Negros but could still support a good number of bat species including endemic ones.

Table 1. Bat species recorded in Balinsasayao Twin Lakes including the distribution and species' Red List status.

FAMILY	SCIENTIFIC NAME	COMMON NAME	DISTRIBUTION (Heaney *et al.* 1998)	STATUS (IUCN, 2010)
Pteropodidae	Cynopterus brachyotis	Com mon short-nosed Fruit Bat	Widespread	LC
	Eonycteris spelaea	Common nectar Bat	Widespread	LC
	Haplonycteris fischeri	Philippine pygmy fruit bat	Philippine Endemic	LC
	Macroglossus minimus	Dagger-toothed Long-nosed fruit bat	Widespread	LC
	Nyctimene rabori,	Philippine tube-nosed fruit bat	Philippine Endemic	EN
	Ptenochirus jagori	Musky fruit bat	Philippine Endemic	LC
	Rousettus Amplexicaudatus	Common rousette	Widespread	LC
	Pteropus pumilus	Little golden-mantled flying fox	Endemic to Philippines and Indonesia	NT
Megadermatidae	*Megaderma spasma*	Common Asian ghost bat	Widespread	LC
Rhinolophidae	*Rhinolophus arcuatus*	Arcuate horseshoe bat	Widespread	LC

Legend: LC- Least Concern; NT- Near Threatened; E – Endangered.

Cynopterus brachyotis (Muller, 1838)

The Short-nosed fruit bat was found to be the most abundant species in most of the sampling sites surveyed. They were commonly caught in open fields, especially areas that have agricultural lands, forest edges, and few were found in a less disturbed habitat. This species have wide tolerance for habitat types. Its total length (mm) measured 52-90; tail length 6-10; ear length 12-16 and forearm 48.1-68.5. According to Heaney *et al.* (2010), this bat is widespread with a stable population and common in secondary forest.

Eonycteris spelaea (Dobson, 1871)

The Common nectar bat was one of the few individuals caught in the area surveyed. They were netted near the fruiting trees like *Ficus* sp. and forest areas. They measured 100-120 mm; tail length 14-16 mm; ear length 21-23 mm and forearm 72.4-79 mm.

This is considered a widespread species with a stable population however, according to Heaney *et al.* (2010), this common nectar bat is heavily hunted in caves and is now vulnerable.

Haplonycteris fischeri (Lawrence, 1939)

The Philippine pygmy fruit bat was one of the most abundant species netted during the sampling periods. This Philippine endemic species is only common in primary forest and it is rare in secondary forest and even absent in agricultural areas (Heaney *et al.* 2010). Yet this species can still be found in secondary areas like Balinsasayo Twin Lakes where there are forest fragment and some cleared areas replaced with agricultural lands. It has declined in recent decades due to habitat destruction by logging and is listed in International Union for the Conservation of Nature and Natural Resources (IUCN) as Vulnerable. However, this species was recently categorized as Least Concern maybe because it could have adapted to the disturbance of the forest. Moreover, this species is a good indicator of the quality and type of the forest. Total length reaches 40-65mm; ear length 8-14 mm and forearm 41.5-60.1mm.

Macroglossus minimus (E. Geoffroy, 1810)

The Dagger-toothed long-nosed fruit bat was considered as one of the commonly caught species in the area surveyed. They were abundantly sampled in area with banana plantation and some disturbed open areas. They measured 58mm -73mm ; tail length 13-17 mm; ear length 10-14 mm and forearm 41.2-69.8 mm. This is considered a widespread species with a stable population and according to Heaney *et al.* (2010), this bat is common in secondary forest and uncommon in primary forests. Their existence is expected.

Nyctimene rabori (Heaney and Peterson, 1984)

The Phillipine tubed-nose fruit bat was only caught in one sampling site. This species was found in

restricted to lowland forest and it was known from 200 m to 1300 m with the presence of forest but rare or uncommon at all known sites (Utzurrum, 1992). Populations have declined severely since 1950 as a result of habitat destruction, and they face extinction on Negros Island, and perhaps elsewhere (Utzurrum, 1992). This species is now considered as Endangered under IUCN (2008). It measured 123mm; tail length 23 mm; ear length 16 mm and forearm 78 mm.

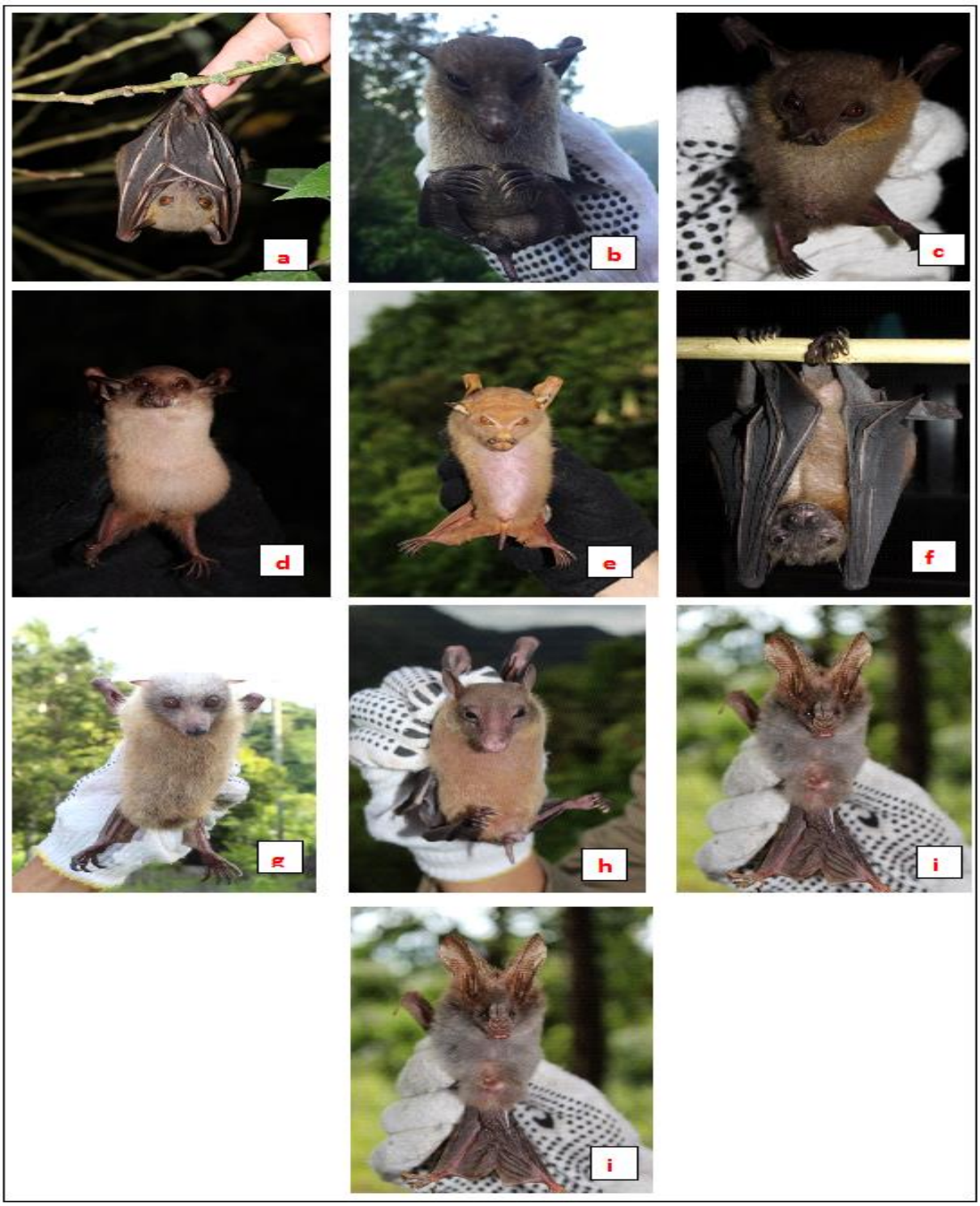

Fig. 2. The 10 species of bats (Megachiroptera and Microchiroptera) caught and recorded in which (a) *C.brachyotis* ; (b) *E. spelaea*; (c) *H. fischeri*; (d) *M. minimus*; (e) *N. rabori*; (f) *P. jagori*; (g) *R. amplexicaudatus*; (h) *P. pumilus*; (i) *M. spasma*; (j) *R. arcuatus.*

Ptenochirus jagori (Peters, 1861)

The Musky fruit bat was one of the commonly netted in the sites. They were recorded in open fields, forest edges and in secondary forest. The result was not anticipated because this endemic species is abundant in primary forest and occasionally present in agricultural areas near forests (Heaney *et al.* 2010). According to Utzurrum (1992), the species has large populations and is generally stable, but has been subjected to continuing habitat destruction. The total length ranged from 78-100 mm; tail length 10-18 mm; ear length 18-22 mm and forearm 83-98.3 mm.

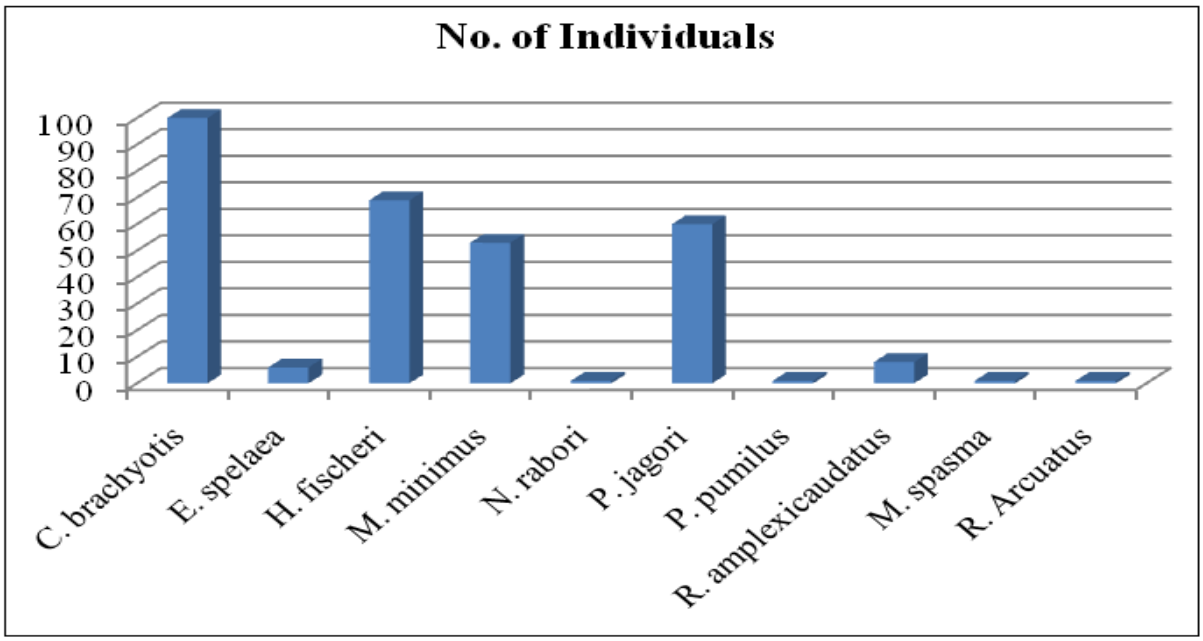

Fig. 3. Total number of individuals captured per species.

Rousettus amplexicaudatus (E. Geoffroy, 1810)

The Common rousette was considered as one of the least recorded fruit bats in the study site. Although they are common in a secondary habitat but the presence of caves is crucial to their existence that were not observed in the area. The total length ranged from 85-120 mm; tail length 15-20 mm; ear length 15-20 mm and forearm 81-89.4 mm. This widespread species are known to roost in caves (Heaney *et al.* 2010) and are locally abundant and stable in agricultural areas, but have been subjected to intense hunting at some cave roosts (Utzurrum, 1992).

Pteropus pumilus (Miller, 1910)

The Little golden-mantled flying fox was only caught through sky netting. The species is usually associated with primary and well-developed secondary lowland forest from sea level to about 1000 m, rarely to 1250m, uncommon outside of forest (Heaney et al., 2010). The bat was caught at about 800 m. This species is most common on small islands and uncommon to rare on larger island according to Utzurrum (1992). Declining as a result of habitat destruction, and it is now categorized as Nearly Threatened (IUCN, 2008). It measured 150 mm; ear length 18 mm and forearm 98.1 mm.

Megaderma spasma (Linnaeus, 1758)

The Common Asian ghost bat was only caught in one sampling station. Its low abundance could be due to its ability to echolocate, thus enabling them to evade the mist nets. Echolocation is a process that is used by animals to orient itself to avoid obstacles in darkness.

Or perhaps, its population is already very small or the area is not a suitable habitat for them. It is noteworthy to mention that this “false vampire bat” is the only species in the Philippines that eats small frog and lizards. The total length ranged from 71 mm; ear length 35 mm and forearm 57.8 mm. This species is widespread and locally common to uncommon in primary and secondary forest (Heaney *et al.* 2010).

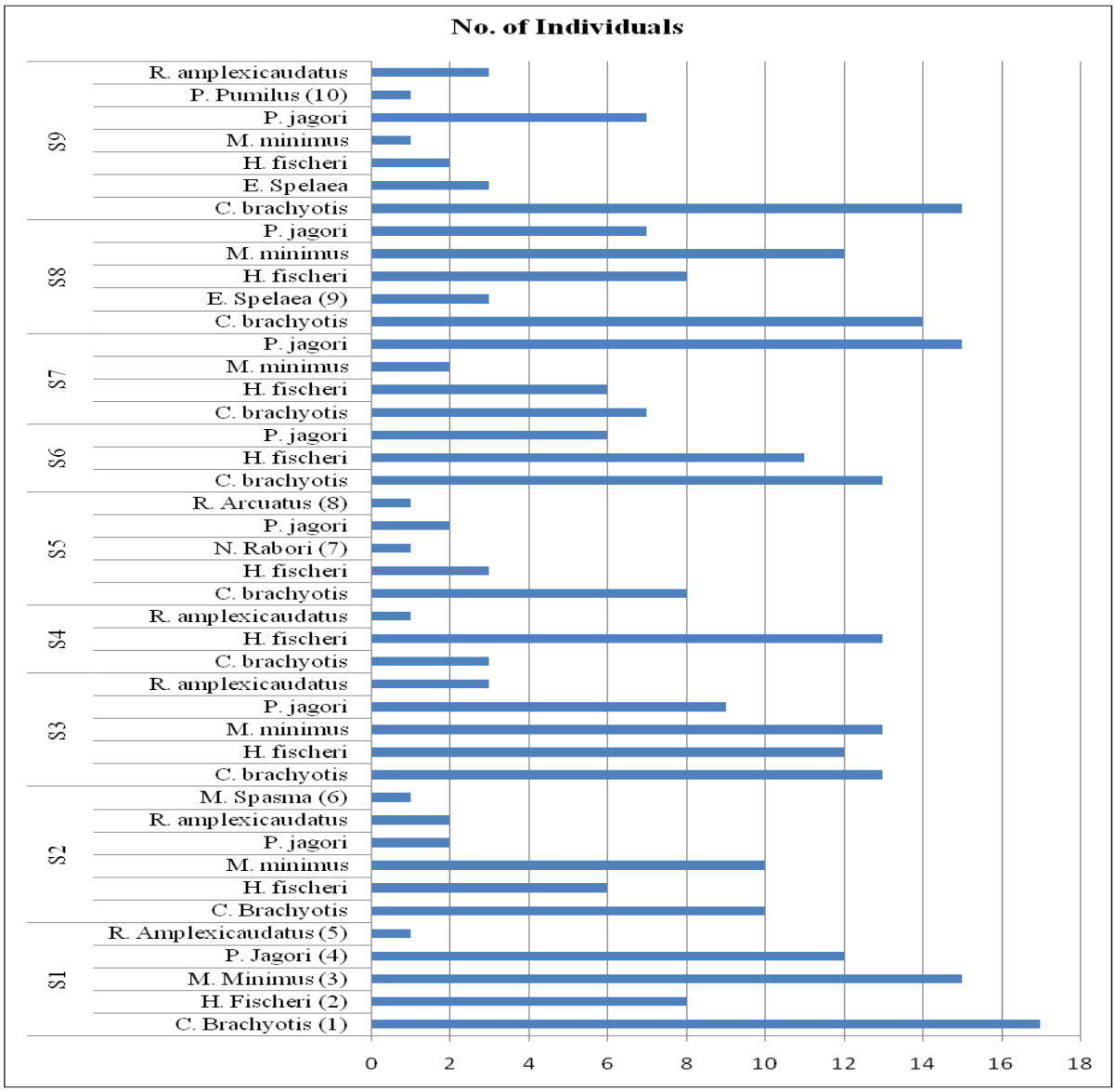

Fig. 4. Total number of individuals per species recorded in each sampling station.

Rhinolophus arcuatus (Peters, 1871)

The Arcuate horseshoe bat was only recorded in one station. According to Heaney *et al.* (1998), this widespread species is locally common in the Philippines. The low capture could be due to the absence of caves in the sampling area and their ability to echolocate as well that they easily had evaded the mist nets. Its total length measured 55 mm; tail length 17 mm; ear length 16 mm and forearm 46.5 mm.

Number of Individuals and Richness of Bat Species

Sampling effort was standardized with more than two weeks using at 20- 6m mist nets. Based on the total number of individuals captured per species, *C. brachyotis* had the most numbers with 100 individuals in all the nine sampling stations (Figures 3 and 4). The said species can tolerate a wide range of habitats enabling it to exist in both non-forest and forest areas. According to Heaney *et al.* (1999), their roosting sites of this species are constructed from the leaves of palm trees that are common in agricultural areas. The presence and abundance of other fruit bats such as *P. jagori* and *H. fischeri* in all sites could be attributed to the vegetation of the area consisting of secondary growth forest. These two species are Philippine endemic. It was observed that fruit bats were more abundant than insect bats. This may be attributed to the capacity of these fruit bats to thrive successfully in almost all types of habitat. The presence of large numbers of fruit trees and the

structural complexity of the forest would also contribute to their success in invading all the sites sampled. The low number of capture of insect bats is probably due to their ability to echolocate, thus enabling them to evade the mist nets. Furthermore, in the event that these bats are captured in mist nets, they have the ability to cut the nets using their sharp teeth thereby freeing themselves.

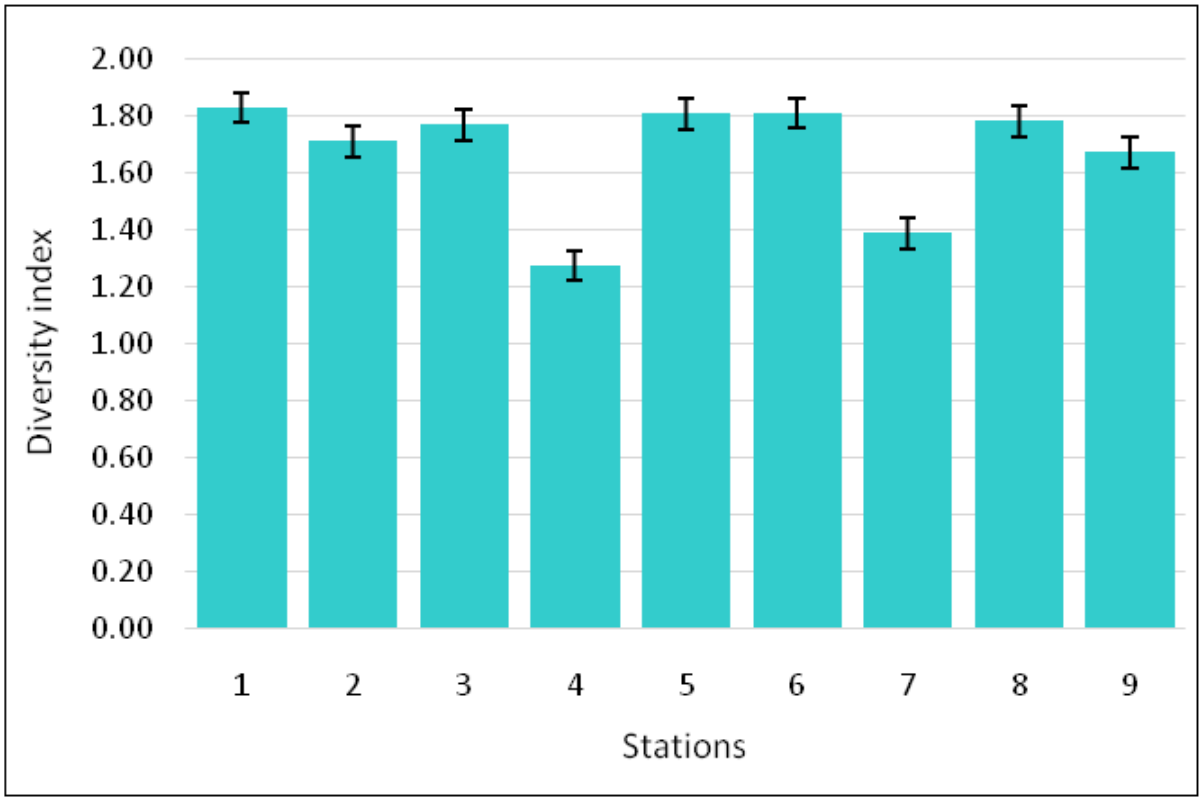

Fig. 5. Species diversity in nine sampling stations.

*Note: least square means in each column with standard deviation are significantly different at $p<0.05$.

The greater amount and wide variety of food resources in the area is probably a factor that makes it a favorable foraging site for the bats. The absence of caves in the area could be the reason for low catch of insect bats. The sites had little differences in their elevation and vegetation, hence, bats being mobile can easily move from one area to another. The higher or lower number of individuals and number of species in the nine sampling stations could be attributed to the availability of suitable places to forage and presence of fruit trees in the area.

Species diversity

Of the nine sampling stations, Station 1 has the highest diversity index with a value of 1.83 while Station 4 with the lowest value of 1.27 (Figure 5). Its high diversity could be due to the variety of vegetation specifically indigenous tree species, fruiting trees, and fern plantation near the forest edge. The site is a secondary forest. Moreover, Stations 4 and 7 differs significantly ($p<0.05$) with the rest of the stations. This could be explained by the differences in terms of vegetation and elevation found in each station. Station 4 has an elevation at about 1000 m that mostly covered with indigenous trees e.g. Almaciga. Growth of young trees was observed that made the area more densely covered. While Station 7 has an elevation at about 900 m, an open area, mostly dominated with cogon and plantation of abaca and coconut trees.

Conclusion

This survey demonstrates that although the area is a secondary forest, it is capable of supporting a variety of frugivorous bat species, most importantly Endangered and Near threatened species. Data

suggests that the area provides food and protection to these species and may be their actual habitat or may just serve as their flyway to and from their actual roosting sites. We suggest continuous semi-annual (dry and wet season) monitoring of bat populations in the area and dissemination of research data to the local communities through Information, Education and Communication (IEC).

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Ethics and security

Specimen collection Gratuitous Permit Number VII-2019-04 (DENR Region VII).

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