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Bats assemblages in Awasian Water Forest Reserve, Tandag City, Surigao del Sur, Philippines

Original Article

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Abstract:

Bats are an integral part of the ecosystem that plays a vital role in its stability. However, their existence is being threatened by uncontrollable anthropogenic activities, and its basic ecological information, especially in Eastern Mindanao, is limited. Thus, the study was conducted to evaluate the assemblage of bats in one of the underexplored sites of Eastern Mindanao Biodiversity Corridor. Mist-netting for a total of 9 net nights was carried out to document the species. A total of 10 species was observed. Among these species, *Cynopterus brachyotis* had the highest relative abundance comprising 53% of the population. Species diversity was relatively higher in the secondary mixed-dipterocarp forest with a Shannon-Weiner Diversity Index (H') of 1.41 compared to the primary dipterocarp forest (H'=1.19). The species *Ptenochirus jagori* and *Rhinolophus subrufus* were the only bats observed with aggregated population distribution pattern. Among the recorded species, six (60%) were assessed as endemic comprising 5 Philippine and 1 Mindanao Endemic, while *Eonycteris robusta* and *Rhinolophus subrufus* were the Near-threatened species recorded. Based on the results, Awasian Water Forest Reserve houses an array of bat species with a high percentage of endemicity.

Key words:

assessment, diversity, endemism, volant mammals

Apstract:

Zajednica slepih miševa u rezervatu Awasian Water Forest, Tandag, Surigao del Sur, Filipini

Slepi miševi su integralni deo ekosistema koji igraju vitalnu ulogu u njegovoj stabilnosti. Ipak, njihovo postojanje je ugroženo nekontrolisanim antropogenim aktivnostima i osnovne ekološke infomacije o njima su ograničene, posebno u istočnom Minadau. Zbog toga, sprovedeno je istraživanje kako bi se procenio raspored slepih miševa na jednoj od neistraženih lokacija koridora biodiverziteta u istočnom Minadau. Kako bi se dokumentovale vrste, izvršeno je postavljanje mreže tokom ukupno 9 noći. Utvrđeno je ukupno 10 vrsta. Među njima, Cynopterus brachyotis imao je najveću relativnu učestalost sačinjavajući 53% populacije. Diverzitet vrsta bio je relativno veći u sekundarnoj mešovitoj dipterokarpnoj šumi sa Shannon-Weiner indeksom diverziteta (H) od 1,41 u poređenju sa primarnom dikterokarpnom šumom (H=1,19). Vrste Ptenochirus jagori i Rhinolophus subrufus su jedini slepi miševi čije su populacije bile grupisanog rasporeda distribucije. Među zabeleženim vrstama, šest (60%) procenjene su kao endemične od koji 5 pripadaju Filipinskim a 1 Mindanao endemitima, dok vrste Eonycteris robusta i Rhinolophus subrufus predstavljaju skoro ugrožene vrste. Na osnovu rezultata, rezervat Awasian Water Forest je stanište za spektar vrsta slepih miševa sa visokim procentom endemizma.

Ključne reči:

procena, diverzitet, endemizam, leteći sisari

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Introduction

The clade Chiroptera includes two extant clades, Megachiroptera (Old World Fruit Bats) and Microchiroptera (echolocating bats). Bats are considered as an ecological indicator because they control pests, pollinate fruit trees, and regenerate forests (Kasso and Balakrishnan, 2013). In the Philippines, bats are deemed as one of the most diverse mammals with at least 80 total extant species comprised of 26 megachiropteran and 54 microchiropteran species (Sedlock et al., 2020). Of these, approximately 40% are reported to be endemic. However, uncontrolled anthropogenic activities, habitat destruction, and disturbances are among the threats that threaten these taxa (Quibod et al., 2019).

The Philippines is previously known for its dense forest in the early 20th century, with a reported forest cover of 95% of the total landmass. However, the continuous deforestation resulted in massive forest denudation, which is estimated to be around 80 to 90% (Butler, 2014). Bats are highly forest-dependent animals, and changes in their habitat could decrease their population and lead to eventual extinction (Mickleburgh et al., 2002). This report is further supported by Murphy and Romanuk (2014) that mammalian species diversity, abundance, and along its mean biomass tend to decrease with increasing human disturbance and continuous habitat loss. For these reasons, the Philippines has been identified as an important area for bat diversity that prioritizes conservation efforts globally (Tanalgo and Hughes, 2018).

Awasian Water Forest Reserve is one of the watersheds of Mt. Hilong-hilong, a biodiversity corridor that lies between the provinces of Agusan and Surigao in the North Eastern Mindanao. Although reported to exhibit rich flora and fauna, these claims are mainly based on scientific expeditions done on the western side of the mountain ecosystem (Agusan); and only a few to none scientific data can be retrieved to represent the eastern side (Surigao). The availability of ecological data is considered vital since it serve as a basis for setting conservation priorities and guidelines (Goodman and Benstead, 2005; Mallari, 2009). Thus, this study was conducted to address the scarcity of scientific information on bat community in the underexplored area of Mt. Hilong-hilong; and provide pragmatic findings that can be utilized for a better understanding of bat assemblage in the area.

Materials and Methods

Place and Duration of the Study

The study was conducted in the Awasian Water Forest Reserve located at Barangay Awasian, Tandag City Surigao del Sur Philippines (**Fig. 1**). The site is geographically located at 9°04'28.9"N and 126°08'34.7"E. The site is one of the watersheds of Mt. Hilong-hilong, situated in the south-eastern part of the mountain ecosystem. The study was conducted from October 1 to 9, 2017, covering nine days of sampling. The site's topography is generally plain, rolling, and gently sloping. The climatic condition in the area falls under the Philippines' Type II climate condition, which is characterized by rainfall distributed throughout the year, with a negligible short dry season (PAGASA, 2011).

Fig. 1. Location map of Mt. Hilong-hilong and spot map of the study site. (BirdLife International, 2020)

Establishment of Sampling Stations and Habitat Assessment

Two 1-km transect lines were established in the study site with an aerial distance from each other of 200 meters. The first transect was considered as Station 1 that cut-across the dipterocarp forest. It was situated at an elevation that extends from 50 to 150 meters above sea level (masl). The dominant plant species were mixtures of *Shorea* spp., *Ficus* spp., and cultivated fruit trees like *Lansium domesticum, Durio zibithenus*, and *Artocarpus odoratissimus*. The soil-litter was thin and dry. The area's distance to the nearest water body (stream) was around 5 to 100 meters. During the sampling period, the temperature ranges from 24 to 30 °C, with a general weather condition of calm-night with a clear sky.

The second transect was designated as Station 2, established along the secondary mixed-dipterocarp forest. It was situated at an elevation of 100 to 250 m a.s.l. with a slightly-closed to closed canopy cover. The station's dominant plant species were *Shorea* spp. of the family Dipterocarpaceae and *Ficus* spp. of family Moraceae. Soil-litter was dry but thicker as compared with Station 1. The area's distance to the nearest stream was around 700 m, and 10 to 100 m from the small spring and stagnant canals. The tem-

perature during the sampling period ranged from 20 to 24 °C, with a general weather condition of gloomy with intermittent rain.

Data Collection and Identification

Along these transects, 21 Mist-nets with a dimension of 4.5 meters long and 12 meters wide with a mesh size of 33 mm were established to capture the bats. Checking of nets was performed from 6:00 PM to 5:00 AM with 30 minutes to 1-hour interval to monitor if there were entangled bats and avoid possible mortality. Captured species were placed into a cloth bag to prevent further stress on the organism and were brought to the processing area for taxonomic examination.

The morphological metrics, which include ear (e), forelimb (fl), hindfoot (hf), tail (t), total length (TL), total body length (TBL), and teeth formation, were noted. These morphological metrics served as the bases for the identification of bat species. The dichotomous key for Philippine bats by Ingle and Heaney (1992) was used for species identification and classification. After taking all the taxonomic information, bats were fed with a sucrose solution and were released back to their captured habitat. However, upon the release, markings for each individual were considered to avoid count duplication if recaptured. On the other hand, dead bat individuals were prepared as voucher specimens and were preserved directly in a 10% formalin solution.

Data Analysis

The Shannon-Weiner Diversity Index (H') was used as the primary index to represent bats' diversity. Along with this, the Species Diversity Equitability (Hmax) or the highest possible diversity index that can be obtained based on the given data set was also determined to assess how close the H' index to the theoretical value. Moreover, the Simpson Diversity Index (1-D) and Species Evenness (J') were calculated to assess the level of species dominance and how evenly distributed the community's population. With an interpretation that if the obtained 1-D and J' values are closer to the value of one, means more diverse, and if it is closer to zero, indicates the opposite. The species rarefaction curve was generated to represent the estimated species richness of bats in the sampled area and assess the bat sampling adequacy.

For determining the species distribution, the statistical analysis – chi-square was used to evaluate if the bat species' populations are either random or aggregated. The level of significance used was 0.05 percent. The distribution probability values that are greater than the level of significance was given a random remark. In contrast, those with below the significance value are considered to have an aggregated distribution pattern. All these analyses were done using the Biodiversity Professional Software 2.0 by Macleece (1997). All ecological and conservation assessments were based on the International Union Conservation for Nature (IUCN) Redlist of 2020.

Results and discussion

Species Richness and Diversity

A total of 196 individuals of bats belonging to three families and nine genera representing ten species were recorded. The species richness is comparatively lower than the records in Loboc Watershed, Mt. Irid, Mt. Kanlaon, Mt. Malindang, Mt. Matutum, Mt. Palali, Polilo Islands, and Sikatuna Protected Landscape. The discrepancy of the number of species observed is attributed to the sample size. The aforementioned studies had a larger sample area that crossed a broader elevational gradient and various vegetation types. On the other note, the result is observed to have a higher richness as compared to the records in Bagumbayan, Bega Watershed, Lowland Forest of Upland Cavite, Mt. Apo, Mt. Kalatungan, Mt. Kitanglad, Mt. Natib, and Cagayan de Oro River. The findings even equate with the number of species observed in the Expansion Site of Mt. Hamiguitan in Davao Oriental and Clarin River in Misamis Occidental - even though these studies also covered a more extensive sampling area with at least four sampling stations (**Tab. 1**).

With this, it could entail that Awasian Water Forest Reserve houses more bats with respect to the ratio and proportion between the species observed and the sampled area. The findings could also imply that the area has better ecological support for bat assemblage since it can hold various species that even surpasses some of those major mountain ecosystems in the Philippines like Mt. Apo and Mt. Kalatungan. A condition that conforms with the findings of Mohagan et al. (2015) that bat richness tends to be higher in a forest ecosystem with more evident ecological support. Not to mention that probable new species could be added to the list if the sampling effort was extended as the species rarefaction depicts (**Fig. 2**). However, the chance is narrowing down as the data saturation is gradually flattening.

As for diversity measures, the Secondary Mixed-dipterocarp forest showed to have a consistently better result in all the calculated diversity analysis compared to the Dipterocarp forest (**Fig. 3**). This result is attributed to a more complex plant structure that results in broader food options for bats. It was noted that at the course of the study, the explicitly observed fruit trees in the Secondary Mixed-dipterocarp forest

Table 1. Summary table of some of the bat studies conducted in the Philippines

Site	Species Richness	Endemism (%)	Dominant Species Observed	References
Bagumbayan, Sultan Kudarat	8	38	*Cynopterus brachyotis*	Tanalgo (2017)
Bega Watershed, Agusan del Sur	8	50	*Cynopterus brachyotis*	Monteclaro and Nuñeza (2015)
Cagayan de Oro River, Misamis Oriental	8	25	*Cynopterus brachyotis*	Lobite et al. (2013)
Clarin River, Misamis Occidental	10	40	*Ptenochirus jagori*	del Socorro et al. (2018)
Loboc Watershed, Bohol	15	40	*Cynopterus brachyotis*	Joe et al. (2012)
Lowland Forest, Upland Cavite	6	67	*	Lagat and Causaren (2018)
Mt. Apo, North Cotabato	8	38	*Cynopterus brachyotis*	Achondro et al. (2014)
Mt. Hamiguitan, Davao Oriental	10	40	*Cynopterus brachyotis*	Amoroso et al. (2019)
Mt. Irid, Southern Sierra Madre	16	19	*Cynopterus brachyotis*	Balete et al. (2013)
Mt. Kalatungan, Bukidnon	6	50	*Haplonycteris fischeri*	Mohagan et al. (2018)
Mt. Kanlaon, Negros Occidental	23	35	*Cynopterus brachyotis*	Deligero et al. (2015)
Mt. Kitanglad, Bukidnon	4	75	*Alionycteris paucidentata*	Mohagan et al. (2015)
Mt. Malindang, Misamis Occidental	19	47	*Cynopterus brachyotis*	Nuñeza et al. (2006)
Mt. Matutum, Saranggani	15	47	*Cynopterus brachyotis*	Nuñeza et al. (2015)
Mt. Natib, Bataan Province	9	33	*Cynopterus brachyotis*	Rickart et al. (2013)
Mt. Palali, Caraballo Mountains	12	42	*Otopteropus cartilagonodus*	Alviola et al. (2011)
Polilo Islands, Calabarzon	25	24	*	Alviola (2010)
Sikatuna Protected Landscape, Bohol	11	44	*Cynopterus brachyotis*	van Vegchel (2003)

like *L. domesticum*, *D. zibithenus*, and *A. odoratissimus* were fruiting, thus, possibly attracting more species and population of bats in the said habitat. Not to mention that the dominant bat-guild observed was fruit bats; hence, the likelihood for the species to congregate in the area is plausible. The observation aligns with the report of Hodgkison and Balding (2004) and Shafie et al. (2011) that bat diversity in a particular area is highly influenced by food availability. Meanwhile, the overall all bat diversity in the area was revealed to be moderate.

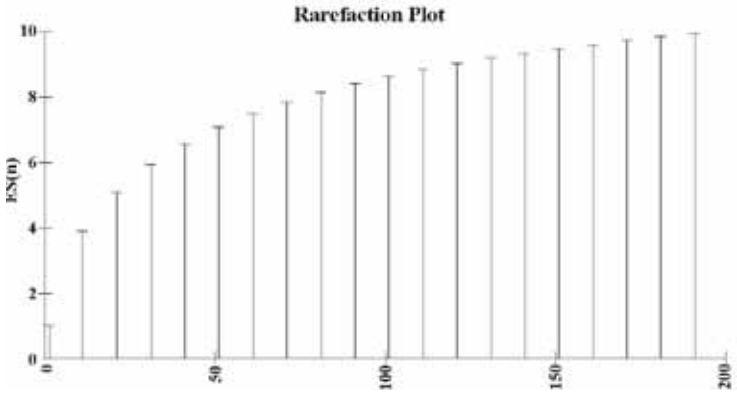

Fig. 2. Species rarefaction plot in Awasian Water Forest Reserve

Among the species, *Cynopterus brachyotis* and *Ptenochirus jagori* were the well-documented bats, wherein the two species comprised 53 and 25 percent of the population, respectively (**Fig. 4**). The result conforms with various studies conducted in the Philippine forests (**Tab. 1**). According to Tan et al. (1998), *C. brachyotis* is widely distributed in the Southeast Asian Region and is common in the Philippine forest. The species also has a wide range of habitat preferences, extending from primary forest to disturbed habitats. While the species *P. jagori* is a common Philippine endemic bat observed in the lowland forests (Sedlock et al., 2008; IUCN, 2020).

Table 2. Distribution pattern of bat's population across habitats

Taxon	Variance	Mean	Chi-sq	df.	Probability	Remarks
PTEROPODIDAE						
Cynopterus brachyotis	24.5	52.5	0.4667	1	0.501796	Random
*Eonycteris robusta***	4.5	1.5	3	1	0.079335	Random
*Haplonycteris fischeri***	0.5	2.5	0.2	1	0.659200	Random
*Harpyionycteris whiteheadi***	0.5	1.5	0.3333	1	0.571066	Random
Macroglossus minimus	12.5	7.5	1.6667	1	0.193468	Random
*Ptenochirus jagori***	420.5	24.5	17.1633	1	0.000066	Aggregated
*Ptenochirus minor**	18	5	3.6	1	0.054660	Random
RHINOLOPHIDAE						
*Rhinolophus subrufus***	12.5	2.5	5	1	0.023993	Aggregated
VESPERTILIONIDAE						
Miniopterus schreibersi	0.5	0.5	1	1	0.318676	Random
Pipistrellus sp.	0.5	0.5	1	1	0.318676	Random

Note: Names with a double asterisk (**) are Philippine endemic bat species. While Names with a single asterisk (*) are Mindanao endemic

Species Distribution Pattern Across Habitats, Endemicity, and Conservation Status

Out of the ten bat populations, the population of *P. jagori* (fruit bat) and *R. subrufus* (insectivorous bat) were noted as aggregated ($p<0.05$). On the other hand, the rest of the bat populations were noted as randomly distributed ($p>0.05$) (**Tab. 2**). The results could suggest two major points: First, for the case of *P. jagori* and *R. subrufus*, necessary ecological support like food source is only found in a particular area or habitat and hence, the reason why the populations of the two bats tend to cluster. Secondly, as for those bat populations with random distribution, the ecological factors that support the population are sporadically distributed in the area; hence, its population is also randomly distributed. This observation conforms with the report of de Jong and Ahlen (1991) and Kush et al. (2004) that food source and supply are essential indicators for bat's regional distribution, especially for insectivorous bats.

Among the ten documented species, five bats are assessed as Philippine endemic, and one is noted as Mindanao endemic. The assessment leads to com-

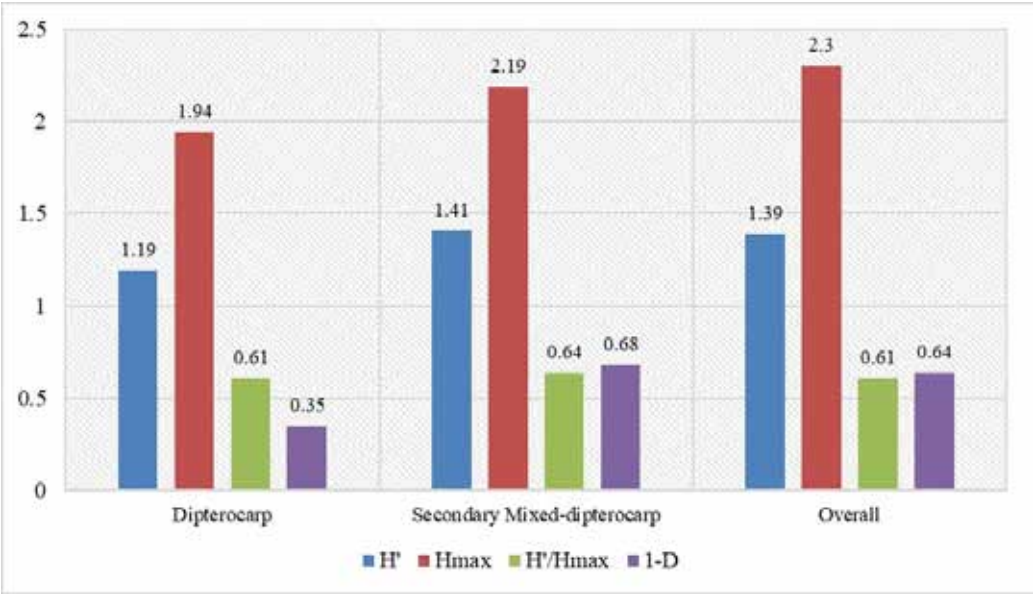

Fig. 3. Comparative bar graph of Shannon-Weiner diversity index (H'), Maximum diversity index value (Hmax), Species diversity equitability (H'/Hmax), and Simpson diversity index (1-D)

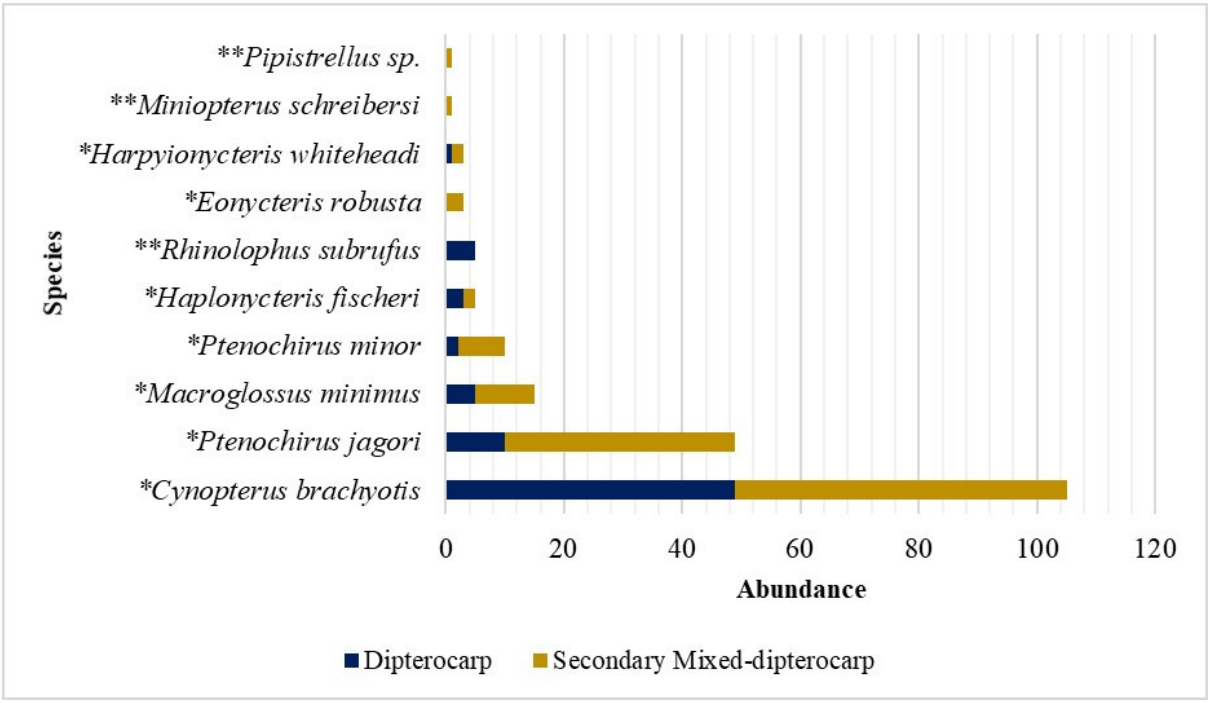

Fig. 4. Comparative abundance of bat species in Awasian Water Forest Reserve. Species name with single asterisk before the scientific name are fruit bats. The rest are insectivorous bats

prehensive documentation of 60% (6/10) total bat endemicity in the area. This total endemism is observed to be relatively higher than the bat endemism reported in various Philippine forests (**Tab. 1**), with an endemism percentage difference that ranges from 10 to 41 percent. Thus, suggesting that the area is an ideal abode to various endemic species. Meanwhile, among the bats, two species (*E. robusta* and *R. subrufus*) are evaluated to be under the Near-threatened category based on the IUCN 2017 and 2020 assessments. Under this criterion, the species are considered to have a decreasing population and are subject to a threatened status if pressures on its existence will be unaddressed. According to IUCN (2020), the primary threat that affects these species' populations is habitat loss. An evident threat in the buffer zones of the watershed.

Conclusions

Awasian Water Forest Reserve harbors various species of bats with high species endemicity. The presence of bat species with random distribution patterns is advantageous to the area, for it contributes to a wider dispersion of ecological services like pollination and seed dispersal. Near-threatened species' presence suggests further conservation efforts considering that threats, especially from anthropogenic pressures, are evident.

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