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Anthropogenic Impacts on Cave-roosting Bats: A Call for Conservation Policy Implementation in Bukidnon, Philippines

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Abstract

Many caves in the Philippines are amongst the most popular natural ecotourism sites, even though most of them are poorly regulated and understudied. This study investigates the anthropogenic impacts of unsustainable eco-tourism and exploitation on cave-roosting bats in Sumalsag Cave, Bukidnon, Mindanao Island, Philippines. The species richness of the cave-roosting bat fauna was determined using the standard mist-netting method and capture-mark and release technique. The conservation status was assessed based on the International Union for Conservation of Nature (IUCN) Red List. Ecological evaluation and assessment of the cave's speleological characteristics and ecological condition was carried out using the Philippines' standard cave assessment protocol. After completing 15 net-nights field sampling with a capture effort of 180 net/hours, results revealed a total of six (6) species of cave-roosting bats which belongs to three (3) families. Two Philippine endemic species, Ptenochirus jagori and Ptenochirus minor were documented including Miniopterus schreibersii, a species classified under near threatened category. Evidence of human activities were considered for identifying the indirect and direct threats on the bat fauna. Destroyed speleothems and speleogens, excavations, modifications of the cave's features as well as graffiti in the cave walls were recorded. This study recommends regulating eco-tourism activities, protecting the endemic and threatened species and promoting natural restoration of the cave by implementing the existing environmental laws.

Keywords: Threatened species, Chiroptera, Ecotourism, Conservation, Mindanao

1. Introduction

Over 1,500 caves have been recorded in the Philippines by the Department of Environment and Natural Resources (DENR) and approximately 37% of the caves are found in the second largest island in the archipelago, Mindanao (Department of Environment and Natural Resources, Protected Areas and Wildlife Bureau [DENR-PAWB], 2008). Despite being used in the country's ecotourism, only 42 new caves were assessed in Mindanao based on the DENR Memorandum Circular No. 2007-04 (Department of Environment and Natural Resources, 2013), the remaining 92% remains poorly known and understudied. Caves serves as important habitat for diverse and unique fauna and home for some of critically endangered species of bats such as the Philippine bare-backed fruit bat, *Dobsonia chapmani,* the country's largest cave-roosting and the first mammal declared to be extinct in the Philippines in 1996, but was rediscovered in 2003 by Paguntalan, Pedregosa, and Gadiana (2004). Out of 79 bat species, 49 species of Philippine bats are roosting in caves (Heaney et al., 2010). Regardless of their ecological and economic importance, many caves in the Philippines are exploited resulting to damages and degradation in the caves' physical characteristics (DENR-PAWB, 2008). Anthropogenic activities like ecotourism and guano mining have resulted to destruction of speleothem, presence of garbage, vandalism, manmade holes and existence of some religious structure in the caves (Tanalgo, Teves, Salvaña, Baleva, & Tabora, 2016). The impact on the resident cave fauna however, is not yet clearly elucidated. Caves fulfill an important role for the survival of bats. Many of which have been widely considered as keystone species. The cave's extremely specific temperatures, patterns of air circulation, physical structures and feeding sites are relatively rare which makes suitable roosting sites for many bats populations (McCracken, 1988). The largest cave in province of Bukidnon and longest cave in Northern Mindanao is the Sumalsag cave system. It is a karst type of cave located in Mt. Palaopao situated between the municipalities Manolo Fortich and

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Sumilao in the province of Bukidnon. The cave is home to some species of cave-roosting bats which are currently being exploited by some local residents as a source of protein. Aside from the unregulated harvesting of guano, illegal mining, treasure hunting, and unauthorized wildlife poaching, the cave is also promoted as one of the province's eco-tourism site. Despite the cave's economic importance, its bio-speleological aspects remains unreported in scientific literature and the various anthropogenic impacts to the cave-roosting bats population badly needs assessment for conservation measures. Hence, this research was conducted to provide the first report on the chiropteran fauna of the Sumalsag Cave which can be utilized by the local government units for implementing environmental laws and policies.

2. Materials and Methods

2.1 The study site

Cave exploration and field investigations were conducted from January 2014 to October 2014 in Sumalsag Cave system situated between Barangay Vista Villa, Sumilao and Dalirig, Manolo Fortich, Bukidnon, Mindanao Island, Philippines (Figure 1).

Figure 1. Location map of study site**.**

It is geographically situated at 08°21'18"N longitude and 124°55'04"E latitude with 642 meters above the sea level elevation. The air temperature in the cave ranges from $23^{o}C$-$24^{o}C$ while the relative humidity was recorded ranging from 76.5% to 84.6%. It is a limestone or karst cave with a distance of approximately 1,859 meters from the cave's main entrance to its exit (Figure 2).

Figure 2. Entrance of Sumalsag Cave.

The cave is surrounded by secondary forest and agricultural vegetation like corn fields and pineapple plantations (Figure 3).

Figure 3. Cleared vegetation and agricultural areas near the cave.

2.2 Sampling method

Five mesh nylon mist nets measuring 12m x 4m x 36mm (Figure 4) were used for capturing the bats during the sampling for three consecutive nights for a total of 15 net-nights.

Figure 4. Mist nets used in capturing the bats**.**

Five mist nets were placed inside the main cave; the first mist net was placed in the entrance of the main cave and the four others were positioned inside in every chamber of the cave. Exit counts were used in counting the species of bats that left the

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cave for 2 consecutive nights, starting at 1700 h up to 2200 h. A total of 15 net-nights were considered for the whole duration of field sampling using the formula of Sedlock, Ingle, and Balete (2011):

- Number of net-nights = number of nets left open X number of nights in operation

Capture effort was likewise computed using the formula of Medellin, Equihua, and Amin (2000):

- Capture effort == $\sum nets\ x \sum hours$

Small pieces of thread were tied to the tarsus of the captured bats. Morphometric data were taken including the sex, age class and different body parameters. After which, they were fed with sugar solution before being released. The key to the bats of Mindanao Island by Ingle and Heaney (1992) was used for the taxonomic identification. Female bats were determined based on the presence of nipples and the examination for a single pair of mammary glands in sub-axillary position, while the males were identified by the presence of a conspicuous penis (Heaney et al., 2010). Age class classification of the bats was based on the ossification of the joints of the wing. The juveniles were identified with swollen joints that were not ossified, sub-adult if partially ossified and lastly fully grow adult if the joints were knobby and fully ossified (Anthony, 1988). Representative voucher bat were euthanized with lidocaine. A gratuitous permit was secured from the Protected Areas and Wildlife Bureau of Department of Environment and Natural Resources in Region 10 for legal collection of voucher specimens. One to two specimens per species were collected for taxonomic confirmations. All collected specimens were labeled properly and deposited in the Zoology Section of the University Museum of Central Mindanao University. Conservation status of identified bats species was based on International Union for Conservation of Nature (2017).

3. Results and Discussions

3.1 Species composition of cave-roosting bats

After completing 15 net-nights with a capture effort of 180 net/hours during the sampling period, a total of 38 individuals from two suborders, three families, five genera and six species of bats were documented in the study site (Table 1). These include members of the family Pteropodidae represented by four species namely, *Ptenochirus jagori*, *Ptenochirus minjor*, *Eonycteris spelaea* and *Rousettus amplexicaudatus.* Both Rhinolophidae

and Vespertilionodae were represented by a single species. The only rhinolophid bat recorded was *Rhinolophus arcuatus-s.* On the other hand *Miniopterus schreibersii* was the only vespertilionid bat documented in this study.

Table 1. Species composition of cave-roosting bats in Sumalsag Cave System.

Suborder	Family	Species
Megachiroptera	Pteropodidae	*Eonycteris spelaea* *Ptenochirus jagori* *Ptenochirus minor* *Rousettus amplexicaudatus*
Microchiroptera	Rhinolophidae	*Rhinolophus arcuatus-s*
	Vespertilionidae	*Miniopterus schreibersii*

3.2 Annotated taxonomic account of species composition with description;

Suborder: Megachiroptera

Family Pteropodidae

- *Eonycteris spelaea* Dobson, 1871 (Figure 5 A)

Common name: Common Dawn Bat

Morphometric measurements: head and tail length, 121-126 mm; head and body length, 106-111 mm; forearm length, 71-80 mm; ear length, 18-21 mm; tail vent length, 12-16 mm; and hind foot length 13-16 mm. This bat has 4 upper incisors. A pair of kidney-shaped glands can be found lateral to the anus.

- *Ptenochirus jagori* Peters, 1861 (Figure 5 B)

Common name: Greater Musky Fruit Bat

Morphometric measurements: head and tail length, 124-127 mm; head and body length, 110 mm; forearm length, 82-84 mm; ear length, 18-20 mm; tail vent length, 14 mm; and hind foot length, 16-17 mm. The *P. jagori* has a short muzzle, two lower incisors and four upper incisors. This species have a dark yellow fur on its upper back.

- *Ptenochirus minor* Yoshiyuki, 1979 (Figure 5 C)

Common name: Lesser Musky Fruit Bat

Morphometric measurements: head and tail length, 102mm; head and body length, 94 mm; forearm length, 69 mm; ear length, 13 mm; tail vent length, 8 mm; and hind foot length 12 mm. This species of bat has a short muzzle, have 4 upper incisors and 2 lower incisors with light yellow fur on its upper back.

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- *Rousettus amplexicaudatus* Geoffroy, 1810 (Figure 5 D)

  Common name: Geoffroy's Rousette

  Morphometric measurements: head and tail length, 128-133 mm; head and body length, 113-119 mm; forearm length, 80-87 mm; ear length, 18-21 mm; tail vent length, 12-16 mm; and hind foot length, 16-19 mm. This bat has a moderately long and tapered muzzle, having 4 upper and 4 lower incisors.

Suborder: Microchiroptera

Family Rhinolophidae

- *Rhinolophus arcuatus-s* Peters, 1871 (Figure 5 E)

  Common name: Arcuate Horseshoe

  Morphometric measurements: head to tail length, 68-69 mm; head and body length, 52-55 mm; forearm length, 42-43 mm; ear length, 19-20 mm; tail vent length, 16-17 mm; and hind foot length, 9-10 mm. The characteristic feature of this bat is a posterior pointed nose-leaf.

Family Vespertilionidae

- *Miniopterus schreibersii* Kuhl, 1817 (Figure 5 F)

  Common name: Common Bent-wing

  Morphometric measurements: head to tail length, 103-106 mm; head and body length, 55-59 mm; forearm length, 42-44 mm; ear length, 11-12 mm; tail vent length, 46-48 mm; and hind foot length; 9-10 mm. Its feet and wrist of has no pads.

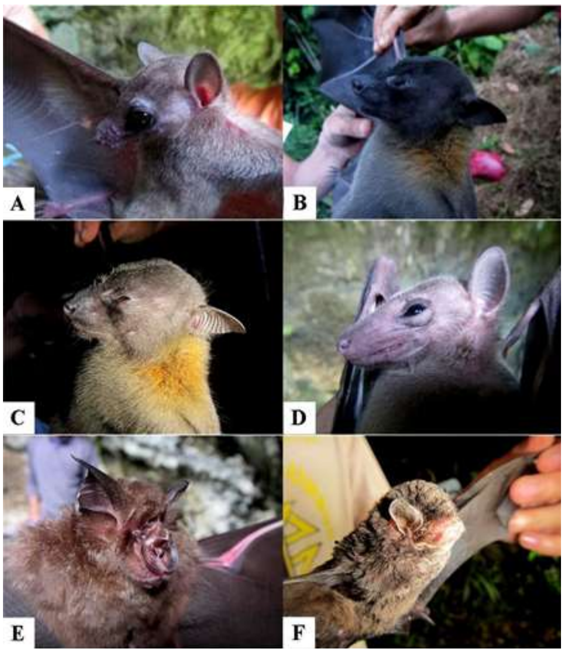

Figure 5. Species composition of bats: **A**. *Eonycteris spelaea* Dobson, 1871; **B**. *Ptenochirus jagori* Peters, 1861; **C**. *Ptenochirus minor* Yoshiyuki, 1979; **D**. *Rousettus amplexicaudatus* Geoffroy, 1810; **E**. *Rhinolophus arcuatus-s* Peters, 1871; **F**. *Miniopterus schreibersi* Kuhl, 1817.

In terms of conservation status, five (5) cave-roosting bat species were categorized as least concerned, these includes *E. spelaea*, *P. jagori*, *P. minor*, *R. amplexicaudatus*, and *R. arcuatus-s.* The verpertilionid bat, *M. schreibersii* is the only species under near threatened category. Two species were considered endemic namely, *P. jagori* which is Philippine endemic, and *P. minor* a Mindanao Island endemic species.

3.4 Assessment of threats in the cave

Based on the assessment, indirect and direct threats to the cave-roosting bats were evident in the area. Indirectly, the cave-roosting bat population faces decline due to negative impacts of anthropogenic activities (Figure 6) such as mining (Figure 7), vandalism (Figure 8) and destruction of cave's physical characteristics (Figure 9) brought about by unregulated ecotourism activities.

The relatively low species composition of cave-roosting bats could be attributed to the presence of various anthropogenic threats and ecological pressures such as changes and disturbances in habitats (Kasso & Balakrishnan, 2013). There is evidence of these activities on the roost sites being linked to the rapid decline of several species of cave roosting bats population (Elliott, 2000).

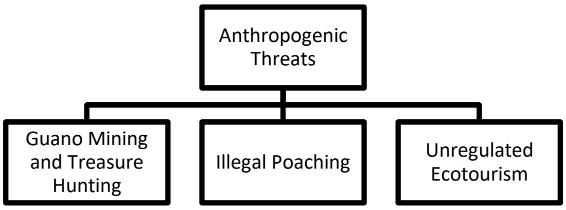

Figure 6. Anthropogenic threats**.**

3.4.1 Guano mining and treasure hunting

Unlawful human activities appeared to be the main threats and cause of destructions in the cave. The excavation inside the cave by treasure hunter and the over collection of guano resulted in many hazardous holes and destruction of the cave's natural structure. Alteration of the cave natural features results in changes in the natural structure of the roost sites as well as affects the flow of the internal climate condition of the cave thereby threatening the cave roosting bats (International Union for Conservation of Nature, 2014). Incidental disturbance and disruptive guano harvesting may also contribute to the declining bat population (Furey & Racey, 2016).

Figure 7. Excavations inside the cave**.**

3.4.2 Bats poaching

Resident cave bats are directly threatened by illegal poaching by the locals using improvised fish nets and guns for bat meat as source of protein. Illegal poaching inside the cave by locals for meat using fishing net, sticks and guns may also exacerbate the rapid decline of bat population (Jenkins & Racey, 2008; Kingston, 2010) and is considered as one of the main threats induced by locals to the roosting bats (Tanalgo et al., 2016). These activities eventually blocked every possible flyways of bats that resulted in massive mortalities. In fact, decaying bodies of bats were discovered hanging in the fishing net placed by the local poachers in the main entrance and exit of the cave. This may partly explain why only adult bats were captured and bat emergence was not observed. Declining of bats population could affect the balance in the ecosystems since they act as prey and predator, pollinators, seed dispersers of economically important plants and plays an important role as natural pest control (Fujita & Tuttle, 1991; Hodgkison, Balding, Zubaid, & Kunz, 2003; Kunz, De Torrez, Bauer, Lobova, & Fleming, 2011).

3.4.3 Unregulated ecotourism

Welcome signage and rules and regulations sign were found in the cave. However, the presence of garbage, destroyed speleothems, graffiti and soil trail were observed indicating signs of negative visitor impact. Infrastructures like religious grottos were found in the entrance of the cave as a further result of habitat modification. These habitat modifications and human activities can negatively impact both bats population and the cave natural features (Tanalgo et al., 2016). Influx of unguided tourist in the area resulted in vandalism in the cave walls (Figure 8). Based on interviews with local people in the community, destruction of the cave's stalagmites and columns was done on purpose to create easy access to the narrow chamber inside the cave.

Figure 8. Vandalism on the cave walls.

One of the primary reason for the decrease of cave-roosting bats population have been reported to be frequent human activities inside the cave (Martin, Leslie, Payton, Puckette, & Hensley, 2003). Aside from the destruction in the cave's natural features, the bright lights produced by tourists also disturb the resident cave-roosting bats. It forbids the bats to roost inside the cave (Agosta, 2002; Aul, Bates, Harrison, & Marimuthu, 2014) and may cause higher death rates in young bats (McCracken, 1989). Such disturbances may cause the bats species to leave the cave resulting in deep effects to ecological services the bats offer like natural pest control, forest reforestation and greatly affects the agriculture sectors (Hodgkison et al., 2003; Jones, Jacobs, Kunz, Willig, & Racey, 2009; Pennisi, Holland, & Stein, 2004). It is unfortunate that the economic importance of bats in providing ecosystem services vital for natural forest succession remains unappreciated.

4. Conclusion

The unregulated ecotourism activities in the cave have many negative impacts to the cave and the cave-roosting bats. Poor management and implementation of the environmental laws resulted in destruction of various natural features of the cave. This may explain the relatively low species richness of cave-roosting bats which is exacerbated by illegal hunting for meat by some locals. This study recommends the proper implementation of the existing environmental laws and local guidelines to protect and conserve all wildlife especially the endemic and threatened species.

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