Vol. 11 January 2020
Print ISSN 2094-5019 • Online ISSN 2244-0461
doi: http://dx.doi.org/10.7828/ajob.v11i1.1385

Asian Journal of Biodiversity
This Journal is in the Science
Master Journal List of Clarivate
Zoological Record

Vulnerability Assessment of Cave Bats (Mammalia: Chiroptera) in Key Biodiversity Areas (KBAs) of Central Visayas, Philippines

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ABSTRACT

The caves in the Philippines are habitats for bat species but are threatened by anthropogenic activities. This study assessed the vulnerability of cave bats in three KBAs (Key Biodiversity Areas) of Central Visayas: Mt. Bandilaan in Siquijor (13 caves), Mabinay, Negros Oriental (12 caves), and Rajah Sikatuna Protected Landscape in Bohol (31 caves). The study was conducted between February 14 to September 20, 2019. Field survey methods included mist-netting at the cave entrances and direct observations of roosting sites in each cave. Of the 56 caves surveyed, 36 caves were inhabited by bats. A total of 16 cave-dwelling bat species belonging to 7 families were recorded. Five species are Philippine endemics (*Hipposideros obscurus*, *Hipposideros pygmaeus*, *Ptenochirus jagori*, *Rhinolophus inops*, and *R. rufus*) and three Near-threatened species (*H. lekaguli*, *M. schreibersii*, and *R. rufus*). The Bat Cave Vulnerability Index (BCVI) was adopted to determine priority sites for conservation. Two cave sites (Canganhao in Siquijor and Mambajo in Mabinay), inhabited by relatively high bat populations, were determined high priority levels. We urge the concerned agencies to strengthen conservation measures in these caves. Prevailing threats included treasure hunting, bat hunting, guano extraction, land conversion, locals' illegal entry, graffiti, among others), and tourism activities.

Keywords: cave, chiropteran, extraction, forest, karst, limestone, threats

INTRODUCTION

Bats (Order Chiroptera) provide a wide range of essential ecosystem services ranging from pollination, seed dispersal, pest control, and tourism (Hodgkison et al., 2003; Kunz et al., 2011; Williams-Guillén et al., 2008). Globally, many bat species are under threat due to anthropogenic activities such as hunting, habitat loss, and degradation (Mickleburgh et al., 2002; Jung & Threlfall, 2016; Frick et al., 2019). The Philippines has a fair share of these threats. The latest analysis by Tanalgo & Hughes (2019) revealed that 35% of the 79 bat species are subject to various threats, primarily by logging, agriculture, and hunting.

Caves are important habitats to around 40 species of bats in the Philippines (Tanalgo & Hughes, 2018, 2019). Some cave bat species roost in large groups (sometimes in several thousand) inside caves (Sedlock et al., 2014; Tanalgo & Tabora, 2015; Quibod et al., 2019). However, cave bats face anthropogenic threats such as hunting, unregulated tourism, and limestone mining (Tanalgo & Hughes, 2019). With over 2,500 known caves in the country, managing them poses a great challenge even with those within protected areas. Evidence of declines in cave bat populations is emerging based on recent studies (e.g., Sedlock et al., 2014; Quibod et al., 2019).

In 2001, the Philippine Congress enacted the National Cave & Cave Resources Management Act (Republic Act 9072) to conserve the caves of the country. However, as pointed out by Tanalgo & Hughes (2019), it often focuses on tourism potential and economic values, undermining the protection of cave biodiversity, including cave-dwelling bats. To address this gap, Tanalgo et al. (2018) developed a rapid yet holistic approach to assess the vulnerability status of caves inhabited by bats, which is a significant step towards prioritizing site conservation. This approach, which used an index called BCVI (Bat Cave Vulnerability Index), has been effectively used in various countries (see Quibod et al., 2019).

This study adopted the BCVI approach to assessing the vulnerability status in selected caves within the Key Biodiversity Areas (KBAs) in Central Visayas, central Philippines.

OBJECTIVES OF THE STUDY

The present study aimed to provide baseline information on the physical characteristics of caves, the status of bat species assemblage, including species richness and abundance, in three KBAs (Mt. Bandilaan Natural Park in Siquijor Island, Mabinay in Negros Oriental, and Rajah Sikatuna Protected Landscape in Bohol) in Central Visayas. Most importantly, this study also aimed to determine the priority levels of the caves inhabited by bats for conservation purposes.

MATERIALS AND METHODS

Study Areas

Mt. Bandilaan Natural Park, Siquijor

The Mt. Bandilaan Forest Ecosystem has 271 hectares of lowland forest under the management of the Provincial Environment & Natural Resources (PENRO) and the Protected Areas and Wildlife Bureau (PAWB). This study surveyed the caves in Mt. Bandilaan (Figure 1B) from February 16–25, 2019. The local government promotes these caves for eco-tourism.

Mabinay, Negros Oriental

The municipality of Mabinay in Negros Oriental is gaining popularity because of its more than four hundred caves. The area is a karst limestone and a rolling landscape characterized by numerous caves and underground river systems (Alcala et al., 2007). The surveyed caves (Figure 1C) are within the four barangays of the said municipality: Bulwang, Lamdas, Namangka, and Paniabonan. This study visited 12 caves from April 23-May 03, 2019.

Rajah Sikatuna Protected Landscape (RSPL), Bohol

RSPL covers an area of 10,452.6 hectares of lowland forested limestone hills with springs and caves. It is the largest of the remaining forests on Bohol Island. Our research team surveyed 31 caves (Figure 1D) within the RSPL, as listed in Table 1. These caves are within the five municipalities inside the premises of RSPL, namely: Batuan, Bilar, Carmen, Dimiao, Sierra Bullones, and Valencia. The cave survey started from July 24–September 20, 2019.

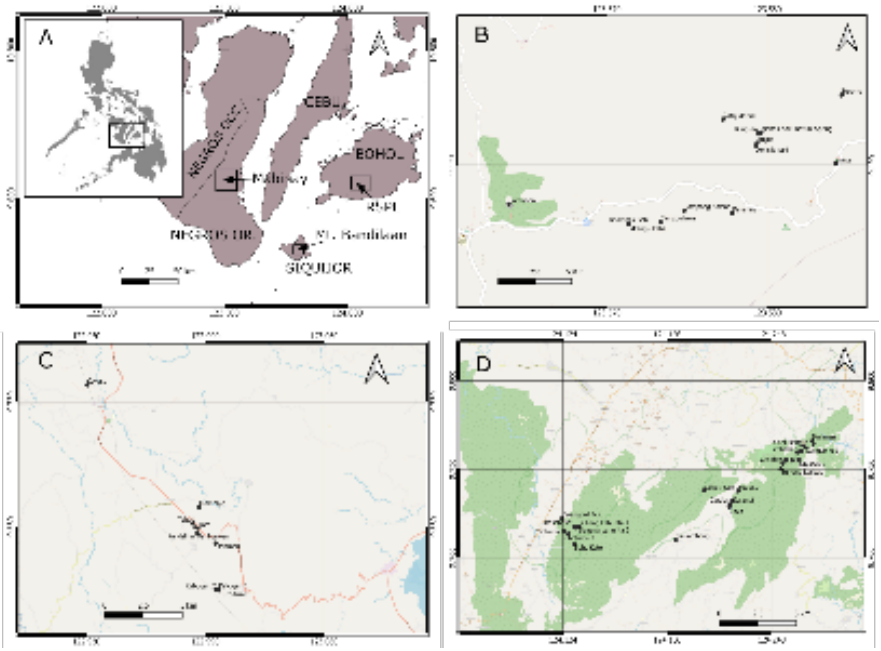

Figure 1. Map of Central Visayas (A): showing the location of the sites surveyed, (B): Mt. Bandila-an, Siquijor, (C): Mabinay, Negros Oriental, and (D): Rajah Sikatuna Protected Landscape. Base maps derived from PhilGIS (www.philgis.org) and openstreetmap.org.

Cave surveys

Before fieldwork, the survey team coordinated with the corresponding local government units and the Department of Environment & Natural Resources (DENR) Offices in Siquijor, Negros Oriental, and Bohol provinces. The team presented the proposal during meetings with management bodies (PENRO, Protected Area Management Board, and local government units) to obtain a Gratuitous Permit (GP).

A reconnaissance survey was done into each cave before sampling activity. During cave surveys, standard caving safety protocols were observed. A GPS (global positioning system) device was used to mark the coordinates of entrances and elevation of cave sites. The length and width of cave entrances, and cave ceilings were measured using a range-finder. Cave length was determined as the total distance traversed from the entrance to the innermost part of the cave using a range-finder.

Anthropogenic activities inside each cave were also noted, such as traces of hunting materials, the presence of diggings for guano extraction, and the presence of graffiti and garbage.

Survey of cave bats

To capture bats, mist nets (3m x 1m) were set near the cave entrance/s. Other team members also searched the inner chambers for the presence of roosting bats. When roost was present, the researchers counted the approximate number of individuals to species level, if possible. Captured individuals were identified to species level based on Heaney et al. (2010) and Heaney and Ingle (1992), marked and immediately released back into the wild right after taking all information like age, sex, morphometric, and other pertinent data.

Bat Cave Vulnerability Index (BCVI)

This study adopted the BCVI index to assess caves inhabited by bats. There are two components of BCVI, as described by Tanalgo et al. (2018). The first component (Biotic Potential Index) includes abundance, species richness, rarity (species-site commonness index), species relative abundance, endemicity, and conservation status. The frequency of the species occurrence was the basis to measure rarity. The endemism and conservation status of each species were based on IUCN (2020) and scored according to the scales provided by Tanalgo et al. (2018). To calculate Biotic Vulnerability Index (BCI, the second component), this study scores each cave site based on six categories: 1) accessibility; 2) cave openings; 3) effort of exploration; 4) tourism activities; 5) cave use, and 6) land use in the vicinity of each cave. Tanalgo et al. (2018) provided descriptions of each category and scale scores. The five categories utilized on-site observations while tourism activities and other cave use (e.g., hunting) supplemented by informal interviews with local guides and other key informants. Aside from field notes on land use and accessibility to cave sites, the latest satellite images (2019) in GoogleEarth were also examined.

RESULTS AND DISCUSSION

Cave characteristics

This study conducted a more comprehensive survey on cave-dwelling bats in the three Key Biodiversity Areas (KBAs) in Central Visayas, namely Siquijor (13 caves), Negros Oriental (12 caves), and Bohol (31 caves). Table 1 summarizes the physical characteristics of all caves (56 total) surveyed. The elevation of the 13 caves in Mt. Bandilaan Natural Park rose from 436 to 523 meters above sea level (mASL). Cave entrances ranged from 0.33-18.5 m^2. Cave ceiling ranged from 0.5-19.5 m. Cave lengths ranged from 5.5-469 m. The caves in Mabinay had elevations ranging from 137-395 mASL. The cave entrances of these caves varied from 2.6-189.7 m^2. Cave ceiling ranged from 1-16 m, while cave lengths ranged from 11-886 m. Mambajo has a perennial underground river that periodically floods during rainy seasons, while the rest of the caves lack this feature. In RSPL, the elevation of these caves ranges from 332-572 mASL, while the entrance ranged from 0.4-163 m^2. Ceiling height ranged from 0.3-10 m, while cave lengths ranged from 2.6-121 m.

Cave bats

Table 1

Cave sites and their physical characteristics and bat assemblage

Cave sites	Physical characteristics						Bat assemblage	
	Latitude	Longitude	Elevation (masl)	Entrance Area (m^2)	Ceiling height (m)	Cave Length (m)	Observed species*	Richness (Abundance**)
Mt. Bandilaan Natural Park, Siquijor								
Ambakag Baki	9.19116	123.57931	513	11.93	1.5–8.5	69.2	HO	1 (2)
Ambakag Baki Nature Spring	9.19194	123.5795	498	0.65	–	n/a	MA	2 (3)
Compbulewan	9.18661	123.57332	522	18.51	2.0–7.4	47.8	None	0 (0)
Compong Karsan	9.18729	123.57482	522	13.35	1.3–8.0	95.3	None	0 (0)
Cang–estaha	9.18622	123.57165	442	3.03	0.9–3.0	69.7	MS	1 (2)
Cang–anhao	9.19277	123.57726	440	6.82	0.5–19.5	78.3	HD, MS, MA, RA	4 (3)
Dakanay	9.18712	123.57782	523	2.19	0.7–2.2	37.3	None	0 (0)
Lunas	9.19007	123.58425	466	4.11	3.3–4.6	5.5	None	0 (0)
Tinamnag Gabi	9.18651	123.57135	436	6.65	1.0–5.3	170.3	None	0 (0)
Toronio	9.19418	123.58461	518	0.73	2.5–3.1	9	None	0 (0)
Tugok	9.19133	123.57934	511	0.65	0.9–2.9	28.2	HO	1 (2)

Table 1 continued.

Cave sites	Physical characteristics						Bat assemblage	
	Latitude	Longitude	Elevation (masl)	Entrance Area (m^2)	Ceiling height (m)	Cave Length (m)	Observed species*	Richness (Abundance**)
Mt. Bandilaan Natural Park, Siquijor								
Bung-aw	9.19191	123.57964	498	0.33	1.7–1.9	33.9	None	0 (0)
Centabon	9.187682	123.563899	497	1.15	1.2–11.5	469	None	0 (0)
Mabinay, Negros Oriental								
Cayasu	9.7393	122.92042	137	167.2	1.1–5.0	886	HD,HL,MSc, RA	4 (2)
Crystal	9.65952	122.98642	271	13.6	2.6–3.6	78.3	None	0 (0)
Kabugan 1	9.62468	122.99789	379	28.3	3.5–13.8	184.9	None	0 (0)
Kabugan 2	9.62464	122.99611	396	38.5	5.5–10.9	190.5	HP,MA,PJ	3 (2)
Mambajo	9.67096	122.98663	192	153.4	2.9–11.5	319.5	ES,MA	2 (4)
Odloman	9.65069	122.99598	243	21.9	3.9–16.2	324.1	ES,HD,RA,RI	4 (2)
Pendelihan	9.6562	122.98555	258	189.7	5.6–9.1	188.6	CB,MA,RP	3 (2)
Penligewan	9.6562	122.98555	258	112.5	6.3–11.9	75.5	CB	1 (1)
Sinkhole	N/A	N/A	N/A	N/A	N/A	N/A	None	0 (0)
Tubod	9.66193	122.98278	196	37.2	1.0–5.2	69.1	HD	1 (1)
Toto	9.65916	122.98571	253	2.6	1.3–7.2	11.1	None	0 (0)
Tuko-tuko	9.6244	122.99785	390	45.9	6.6–12.2	35.9	HD	1 (1)
Rajah Sikatuna Protected Landscape, Bohol								
Bagakay 1	9.75535	124.26376	532	20.7	2.9–3.3	11.3	None	0 (0)
Bagakay 2	9.75529	124.26369	572	15.6	0.7–2.5	17.6	HD	1 (1)
Bangka-bangka	9.71282	124.12731	391	0.4	0.7–1.7	19.3	HD	1 (1)
Basabasa 1	9.71774	124.13038	340	11.1	7.3–2.7	8.3	None	0 (0)
Basabasa 2	9.71716	124.13086	370	6.4	3.2–3.9	4.1	None	0 (0)
Basabasa 3	9.71701	124.13122	418	1.9	2.7–1.9	3.3	None	0 (0)
Binlanan	9.76617	124.27214	457	20.5	1.8–2.7	4.5	PJa	1 (1)
Bodaku	9.737436	124.228028	433	1.7	0.3–7.9	21.7	HD	1 (1)
Buho Katol	9.70721	124.13072	418	2.2	0.7–3.8	52.2	EA	1 (2)
Buhong Anghit	9.75539	124.25568	388	2.9	1.6–8.1	120.6	HD, MA	2 (3)
Buhong Lagbas	9.75007	124.25348	562	10.7	0.9–4.2	15.8	None	0 (0)
Cabakniton	9.737629	124.207908	475	0.7	0.8–2.7	25.1	MS	1 (1)
Cadalas	9.75329	124.25467	524	12.3	1.2–5.3	113.7	MA	1 (3)
Cajanot	9.7324	124.22514	444	1.6	0.7–4.6	2.6	HD	1 (1)
Canlambong	9.70887	124.19099	370	0.9	0.6–1.6	12.4	MS	1 (1)
Canlusong 1	9.76209	124.26805	430	4	1.4–8.0	87.6	HD,MA,RP,RF	4 (2)
Canlusong 2	9.76325	124.26677	444	11.8	2.8–3.3	13.2	MS	1 (1)
Canturna 1	9.71443	124.12498	332	0.8	0.4–3.8	54.6	None	0 (0)

Table 1 continued.

Cave sites	Physical characteristics						Bat assemblage	
	Latitude	Longitude	Elevation (masl)	Entrance Area (m^2)	Ceiling height (m)	Cave Length (m)	Observed species*	Richness (Abundance**)
Mt. Bandilaan Natural Park, Siquijor								
Canturna 2	9.71306	124.12729	387	2.5	0.8–1.0	13.2	HO	1 (1)
Carajan	9.73029	124.12364	448	10.6	0.6–2.5	11.1	HO	1 (2)
Cesabes	9.75525	124.26365	521	162.9	6.6–10.0	35.2	RIa	1 (1)
Duangon 1	9.72228	124.12363	421	26.7	2.2–6.3	80.7	EA,HD,PIa	3 (2)
Duangon 2	9.72228	124.12363	421	1.6	0.9–1.8	41.6	MS	1 (1)
Duhang Lahunta 1	9.71754	124.13295	442	0.4	0.6–1.6	29.7	HO	1 (1)
Duhang Lahunta 2	9.7175	124.133333	442	3.6	0.9–1.4	19.3	HO	1 (1)
Ginabsan	9.71664	124.13185	420	19.4	3.5–6.8	9.7	None	0 (0)
Ilaya	9.7288	124.22289	448	10.6	0.6–3.1	80.5	HO	1 (1)
Libho	9.75482	124.26014	460	7.8	2.0–5.4	46	RF	1 (1)
Palabyo	9.76015	124.26557	362	7.1	0.6–5.9	57.3	None	0 (0)
Sebukaw	9.76637	124.27283	472	8	2.4–5.9	5.2	PIa	1 (1)
Simbehan	9.7594	124.26309	433	28.1	3.5–10.5	43	MS,PIa	2 (1)

* Bat species observed: CB = *Cynopterus brachyotis*; EA = *Emballonura alecto*; ES = *Eonycteris spelaea*; HD = *Hipposideros diadema*; HL = *Hipposideros lekaguli*;

HO = *Hipposideros obscurus*; HP = *Hipposideros pygmaeus*; MS = *Megaderma spasma*; MA = *Miniopterus australis*; MSc = *Miniopterus schreibersi*; PJ = *Pipistrellus javanicus*; PJa = *Ptenochirus jagori*; RA = *Rhinolophus arcuatus*; RI = *Rhinolophus inops*; RP = *Rhinolophus philippinensis*; and RF = *Rhinolophus rufus*

** Abundance scale from Quibod et al. (2019): 0 (0 individual); 1 (1–10); 2 (11–100); 3 (101–1,000); 4 (1,001–10,000)

Table 1 also shows the species richness and abundance scales of cave bats in each cave site. Of the 56 caves surveyed, 20 of these were uninhabited by bats. Species richness was generally low, ranging only from one to four species. Only three cave sites had relatively high bat populations: 1) Cang-anhao Cave in Bandilaan (~1,000 individuals comprised of four species, *Hipposideros diadema*, *Miniopterus spasma*, *M. australis*, and *Rhinolophus arcuatus*); 2) Mambajo Cave in Mabinay (~5,000 individuals) belonging to two species (*Eonycteris spelaea* and *M. australis*); and 3) Buhong Anghit Cave in RSPL (~1,000 individuals mainly *H. diadema* with few individuals of *M. australis*.

Table 2

Cave bat species observed in Central Visayas KBAs

Family	Species	Frequency of occurrence in caves	Estimated abundance in all caves*	Endemicity**	IUCN status**
Emballonuridae	*Emballonura alecto*	2	2	Non-endemic	Least Concern
Hipposideridae	*Hipposideros diadema*	7	3	Non-endemic	Least Concern
	Hipposideros lekaguli	1	1	Non-endemic	Near-Threatened
	Hipposideros obscurus	12	3	Endemic	Least Concern
	Hipposideros pygmaeus	1	1	Endemic	Least Concern
Megadermatidae	*Megaderma spasma*	7	2	Non-endemic	Least Concern
Miniopteridae	*Miniopterus australis*	8	3	Non-endemic	Least Concern
	Miniopterus schreibersi	1	1	Non-endemic	Near-Threatened
Pteropodidae	*Cynopterus brachyotis*	2	2	Non-endemic	Least Concern
	Eonycteris spelaea	2	4	Non-endemic	Least Concern
	Ptenochirus jagori	5	2	Endemic	Least Concern
Rhinolophidae	*Rhinolophus arcuatus*	5	3	Non-endemic	Least Concern
	Rhinolophus inops	1	1	Endemic	Least Concern
	Rhinolophus philippinensis	2	2	Non-endemic	Least Concern
	Rhinolophus rufus	2	2	Endemic	Near-Threatened
Vespertilionidae	*Pipistrellus javanicus*	1	1	Non-endemic	Least Concern

* Abundance scale from Quibod et al. (2019): 0 (0 individual); 1 (1–10); 2 (11–100); 3 (101–1,000); 4 (1,001–10,000)

** Endemicity and IUCN status based on IUCN 2020. The IUCN Red List of Threatened Species. Version 2020-1. <https://www.iucnredlist.org>

A total of 16 species of cave bats belonging to seven families were documented during this study. Representative photographs of these species are shown in Figure 2. Two families (Hipposideridae and Rhinolophidae) were represented by four species, while the remaining families were represented by one to three species. The frequency of species occurrence and overall abundance of each species and their corresponding endemicity and IUCN status are shown in Table 2. Of the 16 species, *Hipposideros obscurus* was the most common, found in 12 out of 56 caves. In comparison, five rare species (*H. lekaguli*, *H. pygmaeus*, *Miniopterus schreibersii*, *Rhinolophus inops*, and *Pipistrellus javanicus*) were found only in one cave. The rest of the species were found in 2-8 cave sites. Five species are Philippine endemics (*H. obscurus*, *H. pygmaeus*, *Ptenochirus jagori*, *R. inops*, and *R. rufus*). There were three Near-threatened species (*H. lekaguli, M. schreibersii*, and *R. rufus*), and the rest are considered Least Concern by IUCN (2020).

Figure 2. Representative bats photographed *in situ* during the cave survey in the three key biodiversity areas. From Mt. Bandilaan (A-*Megaderma spasma*, B-*Miniopterus australis*, C-*Hipposideros obscurus*, D-*Rhinolophus arcuatus*), Mabinay (E-*Hipposideros lekaguli*, F-*Miniopterus schreibersiii*, G-*Miniopterus australis*, H-*Hipposideros diadema*, I-*Rhinolophus philippinensis*), and Rajah Sikatuna Protected Landscape (J-*Rhinolophus philippinensis*, K-*Rhinolophus rufus*, L-*Hipposideros diadema*, M-*Hipposideros obscurus*, N-*Megaderma spasma*, O-*Miniopterus australis*, P-*Ptenochirus jagori*).

Vulnerability of cave bats and conservation priority

Table 3

Bat Cave Vulnerability Index (BVCI) Assessment of cave bat population in Central Visayas KBAs

Cave site	BP Score	BP Status*	BV Score	BV Status**	Priority Level***
Mt. Bandilaan Natural Park, Siquijor					
Ambakag Baki	215	4	2.8	B	Low
Ambakag Baki Nature Spring	24,680	3	3.3	C	Medium
Cang–eskaha	329	4	2.5	B	Low
Cang–anhao	130,426	1	2.7	B	High
Tugok	5,363	4	2.3	B	Low
Mabinay, Negros Oriental					
Cayasu	431	4	1.8	A	Low
Kabugan 2	1,115	4	1.5	A	Low
Mambajo	120,815	1	2.3	B	High
Odloman	46	4	2.3	B	Low
Pandalihan	211	4	1.5	A	Low
Panligawan	16	4	1.5	A	Low
Tubod	4	4	1.5	A	Low
Tuko–tuko	9	4	1.8	A	Low
Rajah Sikatuna Protected Landscape, Bohol					
Bagacay 2	9	4	1.7	A	Low
Bangka-bangka	26	4	3.2	C	Low
Binlanan	40	4	2.7	B	Low
Bodaku	43	4	2.2	B	Low
Buho Katol	283	4	2.7	B	Low
Buhong Anghit	45,502	3	2.7	B	Medium
Cabaknitan	3	4	2.5	B	Low
Cadabas	7,303	4	2.7	B	Low

Table 3 continued.

Cave site	BP Score	BP Status*	BV Score	BV Status**	Priority Level***
Cajanot	1	4	2.2	B	Low
Canlambong	3	4	1.8	A	Low
Canlusong 1	2,627	4	1.8	A	Low
Canlusong 2	1	4	2.7	B	Low
Cantuma 2	34	4	3.2	C	Low
Carajan	77	4	2.2	B	Low
Casabas	14	4	1.8	A	Low
Duangon 1	429	4	2.0	B	Low
Duangon 2	1	4	2.0	B	Low
Duhang Lahunta 1	26	4	3.0	C	Low
Duhang Lahunta 2	2	4	2.8	B	Low
Ilaya	13	4	2.2	B	Low
Libho	6	4	2.3	B	Low
Sebukaw	26	4	2.0	B	Low
Simbahan	53	4	2.2	B	Low

BCVI based on Tanalgo et al. (2018):

* 1 (>100,000 points); 2 (60,000 - 100,000); 3 (20,000 - 59,999); 4 (<20,000)

** A (1-1.99); B (2-2.99); C (3-3.99); D (4.00)

*** High (1A, 1B, 2A); Medium (1C, 1D, 2B-D, 3A-D); Low (4A-D)

In terms of priority level based on BCVI (Table 3), two cave sites (Cang-anhao Cave in Bandilaan, Siquijor, and Mambajo Cave in Mabinay, Negros Oriental) were considered of High priority (1B), while two Medium levels, Ambakag Baki Nature Spring Cave (3C) in Bandilaan and Buhong Anghit Cave (3B) in RSPL, were identified. These sites obtained relatively higher scores primarily due to the presence of high bat populations among the sites. The rest of the sites can be considered Low priority (4A-C) sites due to the low population and low species richness of cave bats.

Bat species diversity and abundance

In this study, 16 species of cave-dwelling bats were identified in three Key Biodiversity Areas (KBAs) in Central Visayas, Philippines. According to IUCN (2020), three species are considered Near-Threatened: 1) *Hipposideros lekaguli*, and 2) *Miniopterus schreibersii*, and *Rhinolophus rufus*. The species richness of cave-dwelling bats in each study site appears lower compared to previous studies done on the cave bats in the Philipines. For example, only five species were observed in Rajah Sikatuna Protected Landscape (RSPL) versus 14 species reported by Sedlock et al. (2014), and Phelps et al. (2016) reported 21 species in 56 caves in Bohol. Only five species were recorded in 13 caves in Siquijor, while Sedlock and Gomez (2010) recorded 11 species from 20 caves. In Mabinay, this study reported 11 species in 12 caves surveyed, while Tababa et al. (2012) identified 15 bat species in just four caves. Other studies outside of the Central Visayan region, such as Tanalgo and Tabora (2015), documented 14 bat species in the South-central Mindanao. Mould (2012) found 12 bat species out of the 21 caves surveyed in Panay Island. Alviola et al. (2015) recorded 13 species in 11 caves. Quibod et al. (2019) listed 15 species in 30 caves in Samal Island, Mindanao.

Among the species, the fruitbat *Eonycteris spelaea* was observed in high numbers (approximately 5,000 individuals) in Mambajo Cave in Mabinay. Earlier counts made by Alcala et al. (2007) of these species combined in Mambajo cave were placed close to 4,000 individuals, a figure significantly lower than the count estimates (~7,000) in the earlier survey in May 2010. Tababa et al. (2012) reported a total bat population of 3,000 in Mambajo Cave. Alcala et al. (2007) noted the absence of the rare, Negros Bare-backed Fruit Bat (*Dobsonia chapmani*), which used to inhabit the Mambajo cave in the 1960s, probably a prolonged period of anthropogenic activities caused the extirpation of this rare bat species. Interestingly, all fruitbats observed in the caves of Mt. Bandilaan by MLR Alcala et al. (2011) were no longer encountered by this study, probably due to continued human disturbance such as guano harvesting and treasure hunting.

Priority caves for conservation

There is a pressing concern about the impact of anthropogenic disturbance on the cave-dwelling bats (Quibod et al., 2019). In this study, disturbances included hunting, guano extraction, and tourism activities, which may affect cave bats. The use of BCVI developed by Tanalgo et al. (2018) to determine priority sites has been done in other areas in the Philippines (Quibod et al., 2019). This study identified High (Cang-anhao Cave and Mambajo Cave) and Medium

priority (Ambakag Baki Nature Spring Cave and Buhong Anghit Cave) sites for conservation. These sites harbor relatively high cave bats populations in the three key biodiversity areas. Two areas are already declared under protection status (Mt. Bandilaan Natural Park under the Provincial Environment and Natural Resources and Rajah Sikatuna Protected Landscape under the National Integrated Protected Areas System, Republic Act 7586), while Mabinay caves are being managed for ecotourism by the local government unit. As mandated by the National Cave Act (Republic Act 9072), these caves are technically under protection status. However, extraction activities (hunting of bats, treasure hunting, guano extraction, dumping of garbage) and tourism are still apparent in these areas suggesting a low level of enforcement. These activities are known to have negative impacts on cave bats (Mould 2012; Sedlock et al., 2014; Quibod et al., 2019; Tanalgo et al., 2018).

CONCLUSIONS

This study assessed the status of cave bats in 56 cave sites in three key biodiversity areas in Central Visayas, where a high number of caves occur. Species richness and abundance were generally low, except in few cave sites with remaining high bat populations. However, despite the government's mandate to protect these caves, these sites are further threatened by anthropogenic activities, including hunting, guano extraction, treasure hunting, garbage dumping, the encroachment of farming (land use in cave vicinities), and tourism. The index known as Bat Cave Vulnerability Index (BCVI) was adopted to determine priority sites for conservation. Caves with high populations still exist and are considered under High and Medium priority levels.

RECOMMENDATIONS

We highly recommend the strict implementation of existing laws and regulations to protect these caves. We also urge the government agencies and other key stakeholders to conduct an information and education campaign (IEC) to raise awareness on the importance of caves as habitats for cave-dwelling bats and other wildlife aside from the economic benefits from ecotourism.

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ACKNOWLEDGEMENTS

The authors are grateful to DOST-PCAARRD through CVAARRDEC Consortium for funding the research project. We also thanked Dr. Regucivilla A. Pobar, President, Bohol Island State University (BISU), Dr. Rosein A. Ancheta Jr. President, Cebu Technological University (CTU), Dr. Joel P. Limson, President, Negros Oriental State University (NORSU), and Dr. Imogen T. Quilicot, President, Siquijor State College, (SSC) for their unwavering support to this research project. The issuance of Gratuitous Permits (GPs) from PAMB and DENR Offices is highly appreciated. We are also indebted to Governor Jecoy Villa of the province of Siquijor and mayors Hon. Ernie T. Uy (former mayor) /Hon. Joetery Uy (newly elected mayor) of Mabinay Municipality, Negros Oriental, Hon. Manuel G. Jayectin of Bilar Municipality, Bilar, Bohol, and Hon. Simplicio Maestrado Jr. of Sierre Bullones of Sierra Bullones, Bohol for extending support. Finally, this project would not have been possible without the support provided by the barangay officials and local guides from the afore-mentioned municipalities during the conduct of the study.