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Cave bat fauna of Siargao Island protected landscape and seascape, Philippines

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Abstract. Caves are considered as arks of biodiversity yet the cave fauna of Siargao Island in the Philippines is poorly known. In this study a modified cruising method was used to determine species richness, endemism, and conservation status of bats in 10 caves on Siargao Island. Eight species of bats with 25% endemism were recorded. A relatively higher species richness was observed in Guano Cave in Siargao. No threatened species according to IUCN category was documented. However, various forms of disturbances in the caves were observed that if left unregulated, could threaten the cave bat fauna.

Key Words: biodiversity, conservation, endemism, guano, species richness.

Introduction. Order Chiroptera is the second most diverse and abundant order of mammals with great physiological and ecological diversity (Hutson et al 2001). It contains 1100 species (Simmons 2005) and nearly about 25% are globally threatened (Mickleburgh et al 2002). It is divided into two suborders, Microchiroptera and Megachiroptera (Murray & Kunz 2005), having 202 genera under 18 families (Simmons 2005). Bats (Chiroptera) provide several ecosystem services and reflect the status of the plant populations on which they feed and pollinate as well as the productivity of insect communities (Jones et al 2009). They also serve as prey and predator in the ecosystem (Barragán et al 2010). Bats are the only mammals that have evolved powered flight. They made it possible to seek shelter in different types of structure (Murray & Kunz 2005). Many species roost in caves, foliage, rock crevices, hollows of trees, beneath exfoliating bark, and different man-made structures (Jones et al 2009). They are the only group of vertebrates that have successfully exploited caves for permanent shelter (Kunz 1982).

Caves are the world's most remote and fragile wilderness (Jones 2009) that frequently serve as a refuge for wild animals and other organisms. They provide more stable environment and are important hibernation sites for many bat species (Gunn 2004). Caves also serve as roost sites for solitary bats and groups ranging up to the largest known mammalian aggregation (Kunz 1982). Cave roosting bats are keystone species because their guano provides vital nutrients for cave ecosystems and is often the basis of a cave's food chain (Jones & Dale 2010). They are known in all continents except Antarctica and are most diverse in tropical regions (Murray & Kunz 2005).

The Philippines has over 1, 500 caves which serve as a home to diverse flora and fauna (Tuttle & Moreno 2005) including the large and diverse mammalian fauna of over 170 species (Ingle & Heaney 1992). Seventy one of these species are bats with 24 endemic species (Heaney et al 1987).This is exceptionally high value of endemism in the world (Heaney et al 2010). Several reports on recent discoveries of cave vertebrate species are documented in the country (Brown & Alcala 2000; Diesmos et al 2002; Siler et al 2007; Siler et al 2009; Rosler et al 2006; Sedlock et al 2008; Linkem et al 2010; Lobite et al 2013). But still there are new species being discovered such as *Styloctenium mindorensis* commonly known as Mindoro stripe-faced Fruit Bat (Esselstyn 2007). Mindanao, the second largest island in the Philippines, has 37% of the country's number of caves (PAWB-DENR 2008). Over 40 species of Philippine bats are known to roost in caves (Heaney et al 2010). Most of the country's caves are in peril due to hunting, mining, illegal collections of cave resources, rapid urbanization, and the lack of statutory protection (Jones 2009).

Siargao Island, which is located in the province of Surigao del Norte, is recognized as a protected landscape and seascape since 1996. Studies on cave crickets (Novises & Nuñeza 2014), ants (Batucan & Nuñeza 2013), spiders (Cabili & Nuñeza 2014), and cockroaches (Mag-Usara & Nuñeza 2014) have been reported. However, baseline data on cave bats are lacking. This study determined the species richness, endemism, and conservation status of the cave-dwelling bat fauna in 10 caves on Siargao Island.

Material and Method

Sampling sites. Sampling was conducted in 10 caves located in the municipalities of Burgos, Del Carmen, General Luna and Sta. Monica on Siargao Island (Figure 1).

Figure 1. Map showing the four municipalities on Siargao Island where the sampling sites are located (Google Maps 2014).

Cave sites

Cave A, Buho Cave - is located in Brgy. Consuelo, General Luna (9^o 48' 11" N and 126^o 06' 22.6" E; elevation at 62 meters above sea level) and is 700 meters (m) from the main road. It is near an agricultural area. The cave has two openings. The first opening or the main entrance is an easy-walk-through, 8.67 m in diameter while the second opening, 5 m in diameter, is sloping and located at the end of the cave. Total cave length is four meters and the cave has only one chamber. Accessible depth is two meters. Accessible area is 750 m^2. Water bodies and flood depth marking were absent. Guano material with a depth of about 1 inch was present 30 m from the main entrance.

Stalactites and stalagmites were present, but the latter were very few all throughout the cave. Boulders were present from the main entrance to the twilight zone. Muddy soil substrate with a depth of 4 inches was present 35 m from the main entrance. External cave ambient temperature was 27.6^oC. Twilight zone ambient temperature was 28.8^oC; ground surface 29.7^oC; wall surface 28.2^oC; roof surface 28^oC; and relative humidity 81%. Inner recess zone ambient temperature was 28^oC; ground surface 27.7^oC; wall surface 27.9^oC; roof surface 27.8^oC; and relative humidity 85%. Light was 2.9 lux, taken 31 m from the first opening, and 2.5 lux, taken 5 m from the second opening. Signs of human disturbances were wooden poles, broken stalagmites, and ground holes for treasure hunting. This cave is utilized as a wildlife habitat and a site for spelunking, and treasure hunting.

Cave B, Bulod Cave 1 - is located in Brgy. Antipolo, Del Carmen (9^o 49' 07.6" N and 126^o 00' 48.7" E) at an elevation of 47 meters above sea level (masl). It is near an agricultural area and is about 500 m from the main road. It has one opening, but not easily accessible due to the entrance size which is only 1 m in diameter. Total cave length is 40 m, and the cave has no chamber. Accessible depth relative to the entrance was 1.5 m. Accessible area was 41 m^2. Water bodies and flood depth marking were absent. Guano material was absent. Stalactites and stalagmites were present but the latter were abundant only at the inner recess zone. Boulders were absent. Muddy soil substrate with a depth of 5 inches was present all throughout. External cave ambient temperature was 31^oC. Twilight zone ambient temperature was 30.6^oC; ground surface 30^oC; wall surface 30.6^oC; roof surface 30.5^oC; and relative humidity 77%. Inner recess zone ambient temperature was 30.7^oC; ground surface 30.5^oC; wall surface 30.6^oC; roof surface 30.4^oC; and relative humidity 80%. Light was 2.6 lux, taken 4 m from the opening. Signs of human disturbances inside the cave were absent. This cave is a wildlife habitat, but according to the local guides, this cave was previously utilized as a bird's nest collection site.

Cave C, Bulod Cave 2 - is located 500 m from the main road in Brgy. Antipolo, Del Carmen (9^o 49' 07.7" N and 126^o 00' 48.7" E) at an elevation of 44 masl. It has one opening with entrance not easily accessible due to small size (1 m in diameter). Total cave length is 40 m and has no chamber. Accessible area was 41 m^2. Water bodies and flood depth marking were absent. Guano material was absent. Stalactites and stalagmites were present, but the latter were present only at the inner recess zone. Boulders were absent. Muddy soil substrate with depth of four inches was present all throughout the cave. External cave ambient temperature was 30.4^oC. Twilight zone ambient temperature was 30.2^oC; ground surface 30^oC; wall surface 30.1^oC; roof surface 29.9^oC; and relative humidity 79%. Inner recess zone ambient temperature was 28.5^o C; ground surface 30.5^oC; wall surface 30.6^oC; roof surface 30.4^oC; and relative humidity 87%. Light was 4 lux, taken 5 m from the main entrance. The cave entrance was gated with wood slabs. There were no signs of human disturbances inside the cave. This cave is a wildlife habitat, but local guides said that this cave was once a bird's nest collection site.

Cave D, Million-bat Cave - is located in Brgy. Antipolo, Del Carmen (9^o 49' 38.2" N and 126^o 00' 55.7" E) at an elevation of 57 masl. It is 1500 m from the main road. It has one opening, about 5 m in diameter with entrance slightly sloping but an easy-walk-through. Total cave length is 140 m and the cave has only one chamber. Accessible depth relative to the opening was 1 m. Accessible area was 1400 m^2. Water bodies and flood depth markings were absent. Guano material was present 30 m from the main entrance with depth of 2 ft. Stalactites and several stalagmites were present with very few columns. Boulders were present at the entrance zone and at the inner recess zone. Muddy soil substrate with depth ranging from 1-2 inches was present 100 m from the entrance. External cave ambient temperature was 30.5^o C. Twilight zone ambient temperature was 30^oC; ground surface 30^oC; wall surface 30.1^oC; roof surface 29^oC; and relative humidity 74%. Inner recess zone ambient temperature was 28.9^oC; ground surface 28.7^oC; wall surface 28.5^{o}C; roof surface 28^{o}C; and relative humidity 87%. Light was 1.4 lux, taken 15 m from the main entrance. Signs of human disturbances seen inside the cave were liquor bottles and broken stalagmites. This cave is utilized as a wildlife habitat and a site for guano collection.

Cave E, Naogon Cave - is located in Brgy. Antipolo, Del Carmen (9^o 49' 38.1" N and 126 ^{o}00' 55.7" E) at an elevation of 60 masl. It is located 1500 m from the main road. The cave has one vertical hardly accessible entrance, 3 m in diameter, which required rappelling. Accessed cave length was 20 m, and the cave has no chamber. Accessible depth relative to the opening was 1 m. Accessed area was 100 m^2. Underground pool was present but was hazardous to reach. Flood depth marking was 4 m. Guano material was absent. Only stalactites were present, no stalagmites. Muddy soil substrate had a maximum depth of 7 inches. External cave ambient temperature was 29^{o}C. Twilight zone ambient temperature was 29.7^{o}C; ground surface 28.8^{o}C; wall surface 29.6^{o}C; roof surface 29^{o}C; and relative humidity 84%. Light was 4.2 lux, taken 1 m from the main entrance. Signs of human disturbances were absent. The cave is utilized as a wildlife habitat and also appears to be a treasure hunting area.

Cave F, Sumiyot Cave - is located in Brgy. Poblacion 1, Burgos (9^o 45' 49.1" N and 126^o 02' 21.4"; elevation of 16 masl) about 400 m from the main road. It has one opening, 2.5 m in diameter but is sloping and not an easy-walk-through. Accessed cave length was 30 m, and the cave has no chamber. Accessible depth relative to the entrance was 1 m. Accessed area was 150 m^2. A pool was present at the inner recess zone but was hazardous to reach. Flood depth marking was absent. Guano material was also absent. Stalactites and stalagmites were extremely abundant with several columns. Boulders were present at the twilight zone. Muddy soil substrate at the entrance zone had a maximum depth of 2 in. External cave ambient temperature was 31.1^{o}C. Twilight zone ambient temperature was 30^{o}C; ground surface 32.1^{o}C; wall surface 32^{o}C; roof surface 30.1^{o}C; and relative humidity 77%. The inner recess zone ambient temperature was 30.1^{o}C; ground surface 30^{o}C; wall surface 30^{o}C; roof surface 29.8^{o}C; and relative humidity 81%. Light illuminance was 1.3 lux, taken 3 m from the entrance. Sign of human disturbance was the presence of broken stalagmites. Cave is utilized as a wildlife habitat, and an area for spelunking. The pool inside the cave is occasionally utilized as a recreational site for swimming.

Cave G, Patag Cave - is located in Brgy. Poblacion 2, Burgos (9^o 59' 54.8" N and 126^o 04' 48.4" E; elevation 22 masl). It is located 600 m from the main road. It has one opening, 10 m in diameter. Entrance is sloping but an easy-walk-through. Estimated cave length is 1000 m. Accessible depth relative to the entrance was 5 m. Accessed area, based on the accessed length only, was 3000 m^2 and the cave has no chamber. Stream is present and is flowing out from the cave. Flood depth marking was 0.6 m. Guano material was present and had a depth of 1 in. Stalactites and stalagmites were abundant. Boulders were present at the twilight zone. Muddy soil substrate was present with a maximum depth of 4 in. External cave ambient temperature was 30.1^{o}C. Twilight zone ambient temperature was 30^{o}C; ground surface 30.2^{o}C; wall surface 30.2^{o}C; roof surface 30.3^{o}C; and relative humidity 80%. Inner recess zone ambient temperature was 27^{o}C; ground surface 27^{o}C; wall surface 27.1^{o}C; roof surface 27^{o}C; and relative humidity 97%. Light illuminance was 12.4 lux, taken 7 m from the entrance. Subsurface water temperature was 26.2^{o}C. Water pH was 6.82. Sign of human disturbance was the presence of broken stalagmites. The cave is utilized as a wildlife habitat, a spelunking area, and a water resource to nearby rice fields.

Cave H, Guano Cave - is located in Brgy. Libertad, Sta. Monica (10^o 01' 04.8" N and 126^o 04' 27.2" E; elevation 33 masl) and is 250 m from the main road. It has one easy-walk-through opening, 10 m in diameter, but the walkway to the entrance area of the cave is steep and vertical which requires rappelling to access. Accessed cave length was 70 m and the cave has no chamber. Accessible depth relative to the opening was 1 m.

Accessed area was 2000 m^2. Water bodies and flood depth marking were absent. Guano material with a depth of 2 inches was present at the inner recess zone. Stalactites and stalagmites were present, but the latter were very few. Boulders were present only at the twilight zone. Muddy soil substrate with a depth of 3 in was present at the inner recess zone. External cave ambient temperature was 28.4^{o}C. Twilight zone ambient temperature was 28^o C; ground surface 28.2^{o}C; wall surface 28^{o}C; roof surface 28^{o}C; and relative humidity was 84%. Inner recess zone ambient temperature was 27.4^{o}C; ground surface 27^{o}C; wall surface 27^{o}C; roof surface 27.1^{o}C; and relative humidity 98%. Light illuminance was 7.6 lux, taken 10 m from the entrance. Signs of human disturbances were soft drink bottles, wooden poles which were probably used for hooking something inside the cave, broken speleothems, and man-made holes for treasure hunting. According to the local people, the cave is utilized as an area for guano collection.

Cave I, Cave II, Sta. Monica - is located in Brgy. Libertad, Sta. Monica (9^o 58' 58.5" N and 126 ^{o} 03' 13.1" E; elevation 51 masl). It is 100 m from the main road. It has one opening, 7 m in diameter. The cave is located near grassland and an agricultural area. The opening is sloping and mossy. Accessed cave length was 20 m and the cave has no chamber. Accessible depth relative to the opening was 1 m. Accessed area was 500 m^2. Water bodies and flood depth markings were absent. Guano material was absent. Speleothems were few and monotonous. Stalactites and stalagmites were present at the entrance area, but the latter were absent at the twilight zone. Boulders were absent. Muddy soil substrate was present at the twilight zone with depth of 2 in. External cave ambient temperature was 27.8^{o}C. Twilight zone ambient temperature was 27^{o}C; ground surface 27^{o}C; wall surface 27.6^{o}C; roof surface 26.8^{o}C; and relative humidity 93%. Inner recess zone ambient temperature was 27^{o}C; ground surface 27^{o}C; wall surface 27.2^{o}C; roof surface 27.1^{o}C; and relative humidity 94%. Light was 1.7 lux, taken 15 m from the entrance. Signs of human disturbances were broken speleothems and man-made holes for treasure hunting. Cave is utilized as a wildlife habitat and an area for treasure hunting.

Cave J, Cave III, Sta. Monica - is located in a residential area in Brgy. Libertad, Sta. Monica (9^o 47' 46.2" N and 126^o 06' 27.7" E; elevation 29 masl). It is 30 m from the main road. The cave has one opening, 2 m in diameter, with vertical, not easily accessible entrance. Accessed cave length was 18 m and the cave has no chamber. Accessed area was 108 m^2. Water bodies and flood depth markings were absent. Guano material was absent. Stalactites and stalagmites were completely absent. The cave entirely consists of limestone deposits. Few boulders were present at the inner recess zone. Muddy soil substrate with depth of 3 in was present all throughout the cave. External cave ambient temperature was 28^{o}C. Twilight zone ambient temperature was 27.2^{o}C; ground surface 27.9^{o}C; wall surface 27.9^{o}C; roof surface 27.8^{o}C; and relative humidity 83%. Inner recess zone ambient temperature was 27.2^{o}C; ground surface 27^{o}C; wall surface 27.1^{o}C; roof surface 27^{o}C; and relative humidity 85%. Light was 1.9 lux, taken 4 m from the entrance. Sign of human disturbance was the presence of household trashes inside the cave. Cave is utilized as a wildlife habitat and an incidental trash area.

Sampling method*.* Sampling was done using the modified cruising method on October 28-31, 2011 for 140 man-hours in 10 caves. A gratuitous permit (GP) was obtained from the Department of Environment and Natural Resources-CARAGA region for collection of samples. Mist nets were set on cave entrances and other flyways inside the caves for the collection of bat species. Identification of samples was based on the taxonomic key of Ingle & Heaney (1992). Distribution and conservation status of identified species followed IUCN Red List of Threatened Species (2014). Two voucher specimens were collected per species for species not readily identified in the field. Specimens collected were deposited at the Mindanao State University-Iligan Institute of Technology (MSU-IIT) Natural Science Museum. Cluster analysis was done to determine similarity of cave sites.

Results and Discussion. Eight species of bats were recorded on Siargao Island (Table 1). Ninety percent (90%) of the cave sites on Siargao Island are home to these bats. The same number of bat species was recorded in Cagayan de Oro City, Philippines (Lobite et al 2013). However, a higher number of bats species was recorded on Polillo Island (Alviola 2000) and on Panay Island Philippines (Mould 2012). Bats were absent in Cave J (Cave III, Sta. Monica) which was the nearest cave to a residential area. Studies conducted in the cities of Czech Republic (Gaisler et al 1998) and Australia (Threlfall et al 2012) showed that bat activity and richness are lower in high density residential areas than in low density areas (e.g. suburban, urban fringe) and semi-natural areas. According to Hale et al (2012), bats are sensitive to changing urban form at a species, guild and community levels, and thus negatively affect the presence and activity of bat species. All of the bat species recorded from all cave sites is of least concern status. Endemism is low at 25%. This low percentage of bat endemism in the area could be due to their restricted distribution (Baquero & Tellería 2001) and smaller population (Thomas 1991). Moreover, a small range, disturbance, and limited roost site availabilty combine to threaten endemic bat species (Sewall et al 2003). Figure 2 shows the two endemic species documented in the caves.

Rhinolophus virgo (Andersen, 1905) was the most widespread species occurring in four sites. It is endemic to the Philippines, and is a widespread and moderately common species that occurs in a number of protected areas (Ong et al 2008). In Cave A, Buho Cave, this species co-exists with *Emballonura alecto* (Eydoux and Gervais, 1836) although both are not co-roosting. *R. virgo* roosts in two sites in the inner recess zone of the said cave, on the roof (30 m from the main entrance) and on the roof near the end point of the cave chamber. In Guano Cave where this bat also co-exists with other chiropterans, *R. virgo* was not clearly determined if it co-roosts with other bats since only one individual was captured in the inner recess zone where *Rousettus amplexicaudatus* (É. Geoffroy, 1810) was roosting. The same observation was recorded in Sumiyot Cave and Cave II, Sta. Monica where only one individual of this species was observed. *R. virgo* was also recorded on Panay Island where it hangs freely near the passage down to the lower chamber of the cave (Mould 2012).It was also recorded in Mt. Palali, Luzon Island, Philippines (Alviola et al 2011).

The second most widespread species was *Hipposideros diadema* (E. Geoffroy, 1813) which was present in three cave sites. This species co-exists with other bats in the caves but was not found to be co-roosting. In Million-bat Cave, *H. diadema* was roosting in about five roost sites situated near each other at the inner recess zone. In Patag Cave, its roosts were also located at the inner recess zone, several meters from the roosting sites of *Hipposideros pygmaeus* (Waterhouse, 1843). In Guano Cave, where *H. diadema* co-exists with three other bats, roosting sites were also situated at the inner recess zone, about 90 m from the twilight area. This result coincides with the observation of Payne et al (1985) that this species is known to roost in large colonies with other species of bats. A group of this species was also observed hanging freely on walls in the dark zone in the caves of Panay Island (Mould 2012). This species was also recorded in Sarawak, Malaysia (Rahman et al 2011) having a wide distribution, presumed large population and occurred in a number of protected areas (Csorba et al 2008a).

Hipposideros cervinus (Gould, 1863), *H. pygmaeus* and *R. amplexicaudatus* were found in two caves but only *H. cervinus* was found in caves in only one municipality. Roosting sites of *H. cervinus* were located at the inner recess zone of the two small caves, Bulod Cave 1 and Bulod Cave 2 in Del Carmen, where its members congregated into groups of not more than 20 individuals. The same observation was obtained by Csorba et al (2008e) that this species roosts in caves (especially large caves) and many hundreds of individuals may be encountered at a single roost (Payne et al 1985), thus it is known as cave-dwelling species.

H. pygmaeus was found to roost at the inner recess zone of Patag, about 80 m from the twilight area. This location was different from Guano Cave where the roost was situated at the twilight zone very close to the cave entrance. This species is endemic to the Philippines (Heaney et al 2008), and was also recorded in Northern Sierra Madre Natural Park (Cabauatan et al 2014) and on Polillo Island (Alviola 2000).

R. amplexicaudatus, the only megachiropteran species documented, was roosting at the inner recess zone of the Million-bat and the Guano Caves. Several large colonies of this species consisted of hundreds to thousands of individuals. At the caves where this species was documented, guano deposits were at their thickest. Csorba et al (2008b) stated that this species is a colonial species which forms cave roosts of several thousand individuals.

The microchiropterans *E. alecto, Megaderma spasma* (Linnaeus, 1758), and *Rhinolophus arcuatus* (Peters, 1871) were found to have very limited distribution, found in only one cave. *E. alecto* was recorded in Buho Cave of General Luna. Not more than 10 individuals of this species were roosting in the hollow portion of the roof of the twilight zone of the cave. The same observation was obtained by Hall (1994) that this species was found clinging on the cave walls at the twilight zone. In the Philippines this species is found in protected areas and is dependent on caves and crevices (Csorba et al 2008c).

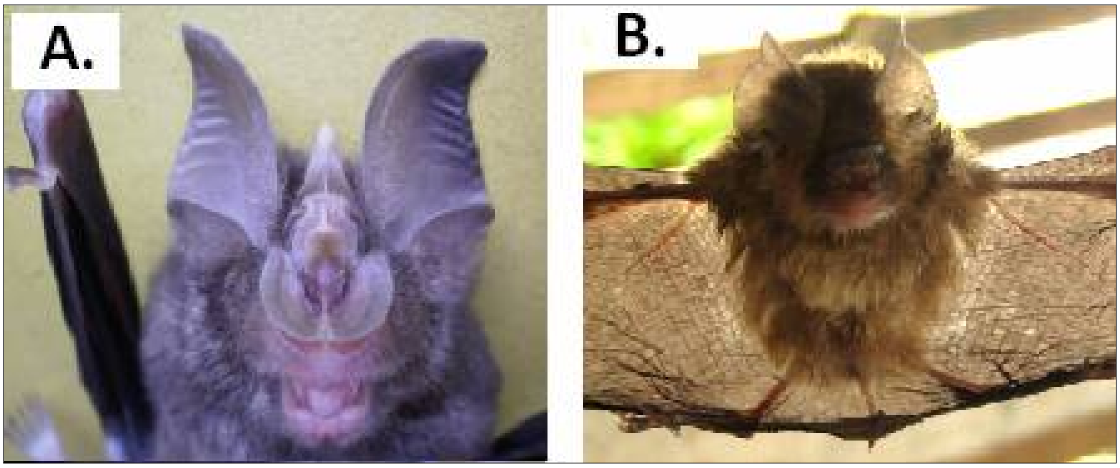

Figure 2. Philippine endemic bats identified in the caves on Siargao Island:
(A) *R. virgo,* (B) *H. pygmaeus*.

M. spasma was the only species roosting at the roof in the twilight zone of Naogon Cave with not more than 10 individuals recorded. Mould (2012) also observed that this species was the most frequently encountered occurring in small number in caves hanging individually and in small cluster from the ceiling at the back of the cavern in dark zone. *M. spasma* was listed by IUCN as Least Concern because of its wide distribution, presumed large population, and occurrence in a number of protected areas Csorba et al (2008d).

R. arcuatus was found roosting at the roof in the transition zone of the Million-bat cave. *H. diadema* and *R. amplexicaudatus* were also found in this cave. *R. arcuatus* has a widespread distribution and is locally common in the Philippines where it roosts in limestone caves in small colonies (Rosell-Ambal et al 2008). *R. arcuatus* was also recorded on Panay Island (Mould 2012), in Sarawak Malaysian Borneo (Rahman et al 2011) and on Polillo Island, Philippines (Alviola 2000).

Figure 3 shows the percentage similarity of one cave site to the other in terms of presence of bat species. There were six caves having some degree of similarity from each other, namely, caves A, I, F, H, G, and D. Under this group, 70% similarity was identified from clades GH and A-FI due to the presence of the only two Philippine endemic species *H. pygmaeus* and *R. virgo*, respectively. The dendrogram also showed that *R. virgo*, a Philippine endemic, is the most widely distributed species in the 10 cave sites sampled. Among all cave sites, caves B and C have 100% similarity since both caves contain only a single species of bat, *H. cervinus.* However, the presence of only one bat species in Clade B-C, and Cave E and the absence of bat species in Cave J resulted to 0% similarity of these caves.

Table 1

Species list of bats in the 10 cave sites on Siargao Island

Species	*Distribution*	*Conservation status*	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*
Emballonura alecto[1]	Non-Philippine endemic	Least concern	+	-	-	-	-	-	-	-	-	-
Hipposideros cervinus[2]	Non-Philippine endemic	Least concern	-	+	+	-	-	-	-	-	-	-
Hipposideros diadema[2]	Non-Philippine endemic	Least concern	-	-	-	+	-	-	+	+	-	-
Hipposideros pygmaeus[2]	Philippine endemic	Least concern	-	-	-	-	-	-	+	+	-	-
Megaderma spasma[3]	Non-Philippine endemic	Least concern	-	-	-	-	+	-	-	-	-	-
Rhinolophus arcuatus[4]	Non-Philippine endemic	Least concern	-	-	-	+	-	-	-	-	-	-
Rhinolophus virgo[4]	Philippine endemic	Least concern	+	-	-	-	-	+	-	+	+	-
Rousettus amplexicaudatus[5]	Non-Philippine endemic	Least concern	-	-	-	+	-	-	-	+	-	-
Species richness			2	1	1	3	1	1	2	4	1	0

[1] Family Emballonuridae, [2] Family Hipposideridae, [3] Family Megadermatidae, [4] Family Rhinolophidae, [5] Family Pteropodidae; (A) Buho Cave, (B) Bulod Cave 1, (C) Bulod Cave 2, (D) Million-bat Cave, (E) Naogon Cave, (F) Sumiyot Cave, (G) Patag Cave, (H) Guano Cave, (I) Cave II, Sta. Monica, (J) Cave III, Sta. Monica.

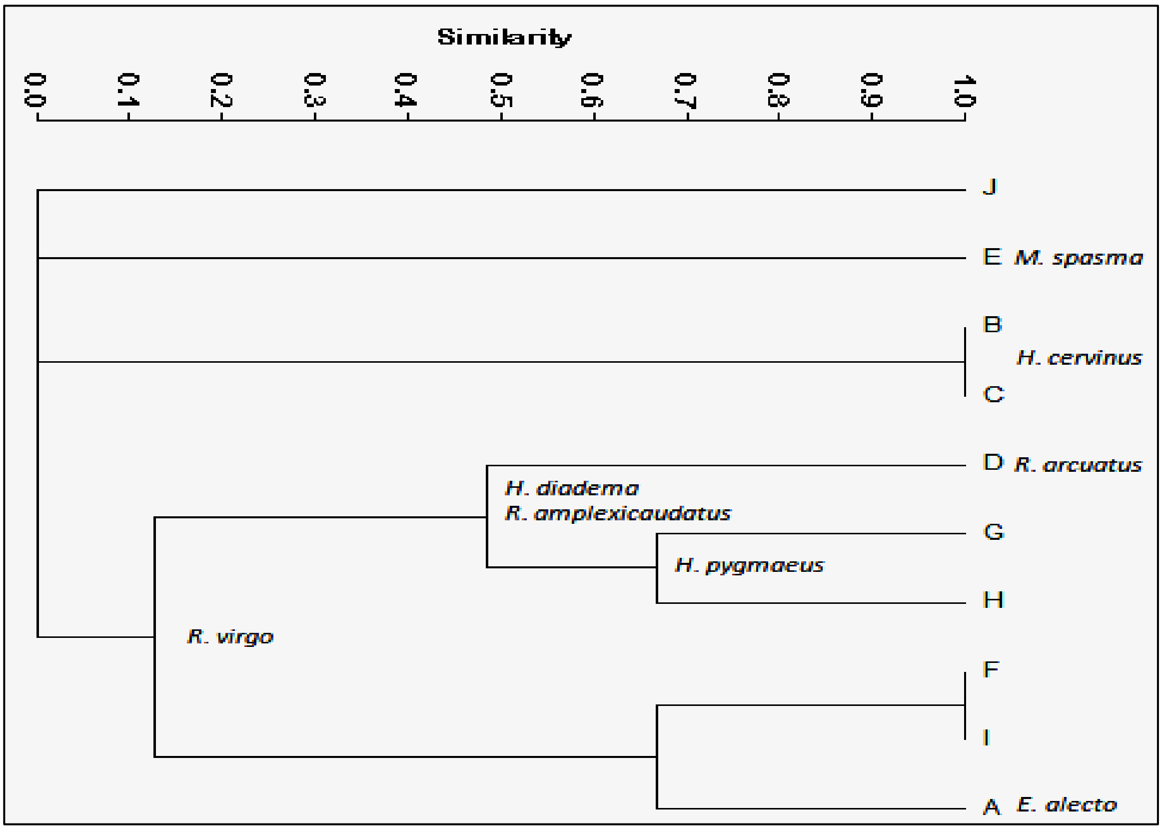

Figure 3. Dendrogram of bat fauna in the 10 cave sites on Siargao Island.

A modified rank system for bat diversity developed by Wynne & Pleytez (2005) was used which originally determines cave bat diversity as: low diversity (< 2 species), medium diversity (3 to 5 species), and high diversity (> 6 species). In this study the ranking system was modified into: low species richness (1-2 species), moderate species richness

(3-4 species), and high species richness (5-6 species). Using this ranking system, Million-bat Cave and the Guano Cave which are relatively large caves had moderate species richness. However, guano collection and other forms of human disturbance in these two caves were observed to be the threats to the bat fauna. McFarlane (1986) noted that in Oxford cave, Jamaica, the bat fauna decreases over the past 70 years due to excessive disturbance associated with guano harvesting and tourism. Moreover, bat populations could decrease in areas where guano is harvested (Mithra 2012). Bats were absent in Cave III, Sta Monica. This absence of bats could be due to disturbance since it is found near a residential area. The presence of household trashes inside this particular cave is a strong evidence of disturbance. Mitchell-Jones (2004) reported that although bats can tolerate a degree of disturbance during hibernation and can apparently become conditioned to a low level of human activity, excessive disturbance will cause bats to abandon a site. Persistent human disturbance is a major cause for the decline in populations of many cave-dwelling bats (Martin et al 2003). The rest of the caves had low species richness (Figure 4). Avila-Flores & Fenton (2005) also recorded low species richness of bats in the urban habitats of Mexico. According to Kasso & Balakrishnan (2013) bat populations appear to be declining presumably in response to human induced environmental stresses like habitat destruction and fragmentation and disturbance to caves.

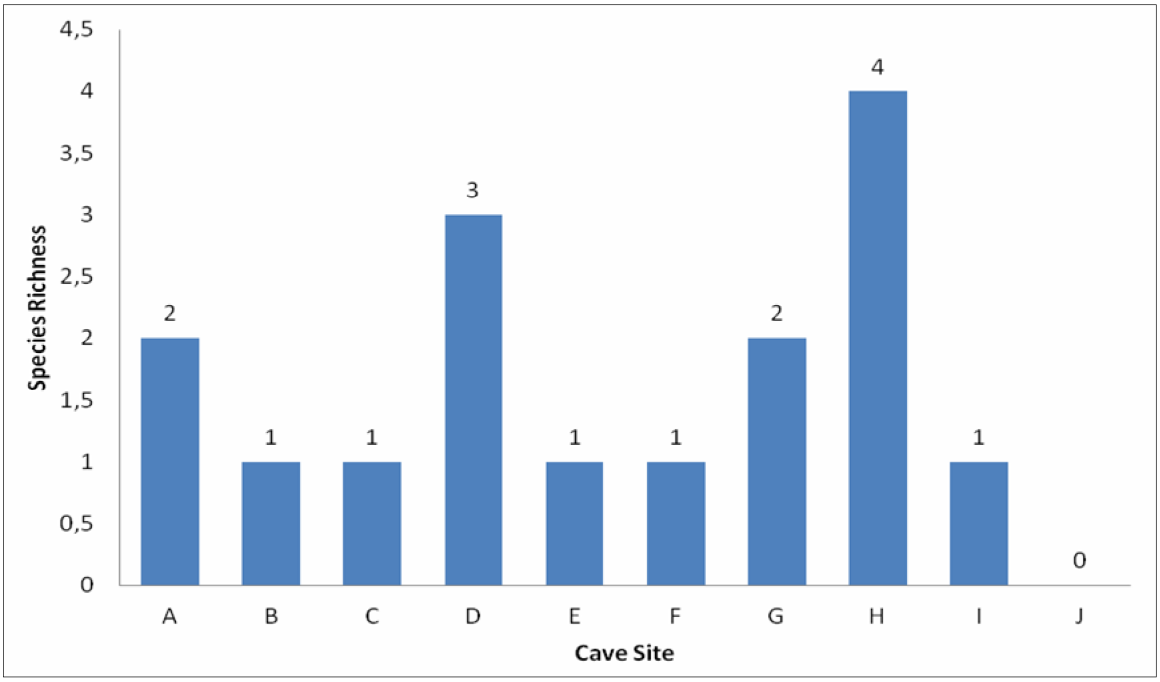

Figure 4. Species richness of bats in 10 cave sites on Siargao Island.

Various forms of disturbances were observed in the caves that could serve as threats to the cave bat fauna. Only caves B (Bulod Cave 1), C (Bulod Cave 2) and E (Naogon Cave), all in the municipality of Del Carmen had no observed anthropogenic signs of disturbance. However, these caves were utilized as sites for bird's nest collection (Caves B and C), and treasure hunting (Cave E) in the past, according to the local guides. The rest of the caves were found to have the following signs of anthropogenic disturbances: broken speleothems, man-made holes for treasure hunting, bottles, wooden poles, and household trashes. Some cave sites are also used for guano collection, spelunking, and swimming activities. Several studies also reported the presence of anthropogenic pressures in caves where bats reside. In a number of caves of Northern Sierra Madre Natural Park in Northern Cagayan Valley, Philippines, man-made disturbances included guano extraction, treasure hunting, wildlife hunting and gathering, vandalism, tourism, and many other illegal activities (Cabauatan et al 2014). In North Vietnam caves, threats included bat harvesting for consumption and tourism development (Furey et al 2011). In

Andaman and Nicobar Islands in India, threats to cave-dwelling animals were collection of edible nests from a certain species of swiftlet, and excessive cave tourism. The latter even caused bat's abandonment of roosts in caves probably influenced by bright lighting and influx of tourists (Aul et al 2014). Bats as bioindicators are particularly affected by various disturbances and man-made stressors which include overhunting, pesticide use, and agricultural intensification (Jones et al 2009). Karst areas, especially in Asia, are indeed experiencing anthropogenic pressures resulting to bat habitat loss and degradation (Furey et al 2011). These threats could be very crucial to the nature of cave-dwelling bats especially in having roosting site specificity. In Yorkshire Dales, the largest karst landscape in the United Kingdom, a large bat population was identified to show high fidelity in swarming to single sites. It was even found that there was a positive correlation between swarming activity of bats and chamber development (Glover & Altringham 2008). The swarming of bats in caves was studied to create a bat-generated microclimate in certain caves making these habitats to be called as hot caves. Hot caves refer to certain cave chambers in the Neotropics characterized by persistently high ambient temperatures produced by the body heat of certain bat species occuring in caves in high densities. However, this characterized microclimate is particularly sensitive to threats of urbanization, mining, tourism and even agricultural development (Ladle et al 2012). The disturbances and threats observed in this study, if left unregulated, could significantly affect bat existence in caves on Siargao Island since caves are vulnerable to disturbance.

Conclusions. *R. virgo,* a Philippine endemic, was the most widespread while another Philippine endemic species, *H. pygmaeus* was observed in two caves. The presence of these endemic species of bats indicates the conservation importance of the caves on Siargao Island. The microchiropterans *E. alecto, M. spasma*, and *R. arcuatus* were found to have very limited distribution. Guano Cave was the most species-rich while no species was present in Cave III, Sta. Monica. The absence of bats suggests a very disturbed cave. All of bat species are listed as least concern with very low endemism (25%). The observed disturbances to the caves on Siargao Island could pose future ecological problems.

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