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# Diurnal roosting preferences of cave-dwelling bats in Northeastern Agusan Del Norte, Mindanao, Philippines

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**Abstract**. The diurnal roosting preferences of bats inside Malague Cave in Buenavista, selected caves in Carmen, and Humilog Cave in Remedios T. Romualdez, Agusan del Norte were surveyed from 9 AM to 5 PM hours, on May 16-21, 2003, May 28-30, 2003, respectively. A total of 198 individuals belonging to five species were identified to roost inside these caves, with three insectivorous species, namely *Emballonura alecto, Taphozous melanopogon* and *Rhinolophus subrufus* and two furgivorous species: *Eonycteris spelaea* and *Rousettus amplexicaudatus. Emballonura alecto* preferred to roost in small cavities and where there is partial illumination while *Rhinolophus subrufus* was observed to roost in partially illuminated to dimly lit areas. Most individuals of these species preferred to hang singly in ceilings and cavities of lower height. On the other hand, *Taphozous melanopogon* roosted in cavities and some cracks and crevices where there is partial illumination. A maternal colony and a nursery colony of *T. melanopogon* were present in the caves of Carmen, Agusan del Norte. Meanwhile, *Eonycteris spelaea* and *Rousettus amplexicaudatus* preferred to cling on walls on areas where there is partial illumination. Some tended to roost in sites where there was total absence of light when the cave was disturbed. It was found out that physical parameters such as illumination, cave size, reliefs and height of roosting sites played significant role in the diurnal roosting preferences of bats. Reproductive activities of some species and the limestone type of the cave as well as the degree of disturbance could also be counted as factors.
**Key Words**: Roosting activities, caves, bats, illumination, limestone.

**Introduction**. The Philippine archipelago is one of the largest aggregations of islands in the world thus, not surprisingly, the country supports a fauna that is exceptionally rich in unique species of animals. Over 170 species are known and about 100 species are endemic to the country (Hauge et al 1986; Heaney 1986, 1991; Koopman 1989). The bat fauna constitutes one of the diverse groups of mammals, with 71 species recorded, 24 of which are endemic to the country (Heaney et al 1987). Of the 1116 identified species of bats worldwide (Simmons 2005), Philippine species are also considered keystone (critical) species in forest and other ecosystems (Barr 1968; Batucan & Nuneza 2013) as they play major roles as pollinators, seed dispersers, guano producers, and insect predators while they forage at night (Barlow et al 2000).

Most bat species live in groups although varying dramatically among species on the roosting sites for shelter and reproductive purposes (Kunz 1982). Thousands or even several million bats may share a roost but many species also live in smaller groups, ranging from a pair to a few hundred. Bats also vary enormously in the range of roost sites, including in the extent of their gregariousness at these sites. Some bat species use plants that are not modified by any biotic or abiotic agents for roosting (Brooke 1990; Kunz et al 1994; Tan et al 1997; Kunz & Lumsden 2003; Kunz & McCracken 1996; Dechmann et al 2005). Others choose enclosed structures such the attics of houses and the insides of hollow trees as day roosts (Kunz 1982).

Many bat species are considered important fauna in caves (Kalko et al 1999) but they are also considered vulnerable because very large numbers may occur in one cave site and any disturbance or environmental changes can affect the population. They are

dependent upon the cave environment for management of their own body temperature and metabolism. They may also depend upon the availability of food in the surrounding countryside. A cave site can also be a maternity site that may contain virtually all the female and juveniles which, when dispersed or disturbed, will spread over an area up to 1,000 square kilometers.

Since insectivorous "Microchiroptera" are nocturnal, spending their days at rest in a 'day roost' and their nights either actively foraging or roosting in 'night roosts' (Anthony & Kunz 1977), the predictability of the emergence event has provided the focus of many research studies (Venables 1943; Church 1957; Erkert 1982; McAney & Fairley 1988; Maier 1992). While there is adequate information on the bat fauna, insufficient information however exists on the knowledge regarding the cave-dwelling species, particularly on their roosting ecology and behavior information, thus this study was conducted. Since there are also a wide range of potential threats to their survival, including habitat destruction, habitat modification, poisoning, reduction of food supply, and human interference (http://www.batcon.org), the current study was considered important in crafting measures to protect their habitat and conserve the cave-dwelling species.

## Methodology

***Study Area***. Three municipalities of Agusan del Norte, in the Northeastern Mindanao, Philippines, were the areas studied for the roosting sites of cave-dwelling bats (Fig. 1). The Municipality of Carmen is the first town strategically located in the Western Agusan Corridor, bounded to the north by the Butuan Bay, on the south by the Municipality of Buenavista, on the east by the Municipality of Nasipit and on the west by the province of Misamis Oriental. The municipality of Buenavista on the other hand, lies at 9 degrees, 55 minutes at north latitude and 125 degrees 25 minutes east longitude on the northern part of Agusan del Norte. It is bounded on the north by Butuan Bay, on the west by Nasipit and Misamis Oriental, on the South by Las Nievas and on the east by the City of Butuan, the capital city of Agusan del Norte. The municipality of Remidios T. Romualdez or RTR is 217 kilometers northeast of the regional center. Its boundaries are Cabadbaran to the north; Magallanes to west; Butuan City to the south; and Sibagat, Agusan del Sur to the east. It is 20 km away from Butuan City. The municipality has a total area of 66,928 hectares.


Fig. 1. (a) Locations of the caves in Agusan del Norte, Mindanao, Philippines, (b-f) Sample of cave mouths varying from being narrow and steep to differences in the degree of illumination.

***Assessment of caves and the roosting sites***. Cave structures were explored regarding the presence of stalagmites, stalactites, holes or cervices. The sizes of relief and chambers were measured using tape measure and calibrated ropes. The caves were described either of limestone or non-limestone type; the degree of illumination was assessed as illuminated, partially illuminated, or totally dark. The air temperature was taken by holding up the thermometer for 5 minutes within the sites. Humidity was taken by tying thermometers in opposite directions together. One of the thermometers had moistened cotton attached to it to get the relative wet humidity. The tied thermometer was then twirled around for 1 to 2 minutes.

***Collection and identification of cave-dwelling bats***. Mist nets were placed across the mouth and inside the selected caves to capture and determine the species composition of cave-dwelling bats. Sweep net was also used to collect bats in reachable roosting sites. The nets were set open for 24 hours during the whole sampling period. Captured bats were temporarily put in a cloth bag before processing, description and identification.

Surveys on the daytime roosting preferences of bats were taken from 9 AM to 5 PM and checked at a two to three hours interval. For every roosting site, the type of relief as well as the species composition of particular relief occupied by bats during the day were assessed. The population size of bats in each roosting sites represents only estimated counts. The type of vegetation outside the caves was also noted. Local names of the plants, including the type of disturbance of the area, were based on interviews of the local residents. Samples of identified and unidentified plants were collected for proper identification and verification, using the available references.

Captured bats were studied immediately after the collection. Measurements on forearm, hind foot, ear, tail vertebra, body, and total length were taken using a vernier caliper. A weighing scale was used in weighing the captured bats. All of these are important aides for the identification of each captured bat. Information on the sex, age, and reproductive status of female bats were also taken. A key to the bats of the Philippine Islands by Ingle & Heaney (1992) was used as guide in identifying the cave bats up to the species level.

In determining the sex of the bats, the presence of conspicuous penis in males and the presence of a single anterior pair of mammary glands and nipples in a subaxillary or anterolateral position in females were observed (Heaney et al 1987).

In classifying bats into age classes, the bats were examined by the degree of ossification of the joints in the digits of the wing. The metacarpal-phalangeal joints were transilluminated with a flashlight. These two plates are visible in juvenile bats but are not found in adults. The shape of the digit joints also differentiated juvenile from adults, where juvenile, the joints are swollen and tampered whereas in adult, the joints are knobby and more distinct from the bone shaft (Anthony 1988).

In determination of lactation among female individuals, their nipples were squeezed to extrude milk. In addition, pregnancy among females was determined by palpation of their embryo (Racey 1988). Captured bats were immediately released back to the cave after processing.

**Results and Discussion**. Five species of bats were observed to inhabit the caves of Beunavista, Carmen and RTR in Agusan del Norte. Three species were insectivorous, namely *Emballonura alecto, Taphozous melanopogon* and *Rhinolophus subrufus* and two were fruit feeders, *Eonycteris spelaea* and *Rousettus amplexicaudatus* (Fig. 2).

*Emballonura alecto*, an insectivorous bat, was observed to roost in a limestone type of cave with partial illumination. It was observed clinging to small cavities, 0.20 – 0.30 meters deep. *E. alecto* roosted in areas with $24^0$ C – $27^0$ C temperature range and a relative humidity range of 85% - 90%. Their average morphometrics include the following: total length - 76 mm, tail - 31.5 mm, hind foot - 7.5 mm, ear - 12.75 mm, forearm - 41.25 mm and 5 g weight.

Fig. 2. "Cave-dwelling bats". (a) *Emballonura alecto, (b) Taphozous melanopogon, (c) Rhinolophus subrufus*, (d) *Eonycteris spelaea,* (e) *Rousettus amplexicaudatus.*

*Taphozous melanopogon* roosts in groups, specifically in crevices and cavities (0.50 – 1.00 m deep) where there is partial illumination. It roosts in areas with temperature range of $26^0$ C – $29^0$ C and relative humidity of 86 % - 94%. Its morphometrics include the following: total length - 91.77 mm, tail - 19.99 mm, hind foot - 13.05 mm, ear - 14.99 mm, forearm - 60.46 mm and a 21.24 g weight.

*Rousettus amplexicaudatus* was observed to cling on ceilings, walls and cavities, which are 0.40 – 0.60 m deep, of a non-limestone cave. This species was observed to roost in partially illuminated areas with a temperature range of $27^0$ C – $29^0$ C and a relative humidity of 69% - 95%. Its average morphometrics include the following: total length - 106.28 mm, tail - 15.85 mm, hind foot - 19.79 mm, ear - 15.92 mm, forearm - 67.64 mm and weight of 66.85 g.

*Emballonura alecto*, an insectivorous bat, was observed to roost in a limestone type of cave with partial illumination. It was observed clinging to small cavities, 0.20 – 0.30 meters deep. *E. alecto* roosted in areas with $24^0$ C – $27^0$ C temperature range and a relative humidity range of 85% - 90%. Their average morphometrics include the following: total length - 76 mm, tail - 31.5 mm, hind foot - 7.5 mm, ear - 12.75 mm, forearm - 41.25 mm and weight of 5 g.

*Rhinonolophus subrufus* belongs to the family Rhinolophidae. This bat species roots in a limestone cave having partial illumination. It clings to ceilings and small cavities measuring 0.20 – 0.40 m deep with a temperature range of $24^0$ C – $28^0$ C and a relative humidity range of 85% - 90%. Its morphometrics include the following: total length - 73.8 mm, tail - 17.5 mm, hind foot - 11.3 mm, ear - 20 mm, forearm - 53.2 mm and a weight of 17 g.

***Roosting Site Assessment***

***Brgy. Guinabsan, Buenavista, Agusan del Norte***. The town is located at $8^0$54.1436N $125^0$25.8974E and with an altitude of 148 m above sea level. There is only one non-limestone cave named Malague Cave located a few kilometers away from the

town center. The cave has an opening of 1.75 m length, 4.5 m width and 3.0 m height (Fig. 3). This cave is characterized by partial illumination to total darkness in the deeper portion of the cave. This three-chambered cave has a temperature ranging from $27^0$ C-$29^0$C and an average relative humidity of 67%. The vegetation outside is composed of jackfruit (*Atrocarpus heterophyllus),* avocado *(Persia americana* Mill), coconut tree *(Cocos nucifera)*, balite *(Ficus sp.)* and some unidentified plants. This cave has guano substrate of up to 0.28 m deep. Swiftlets are inhabiting the vicinity of the cave mouth.

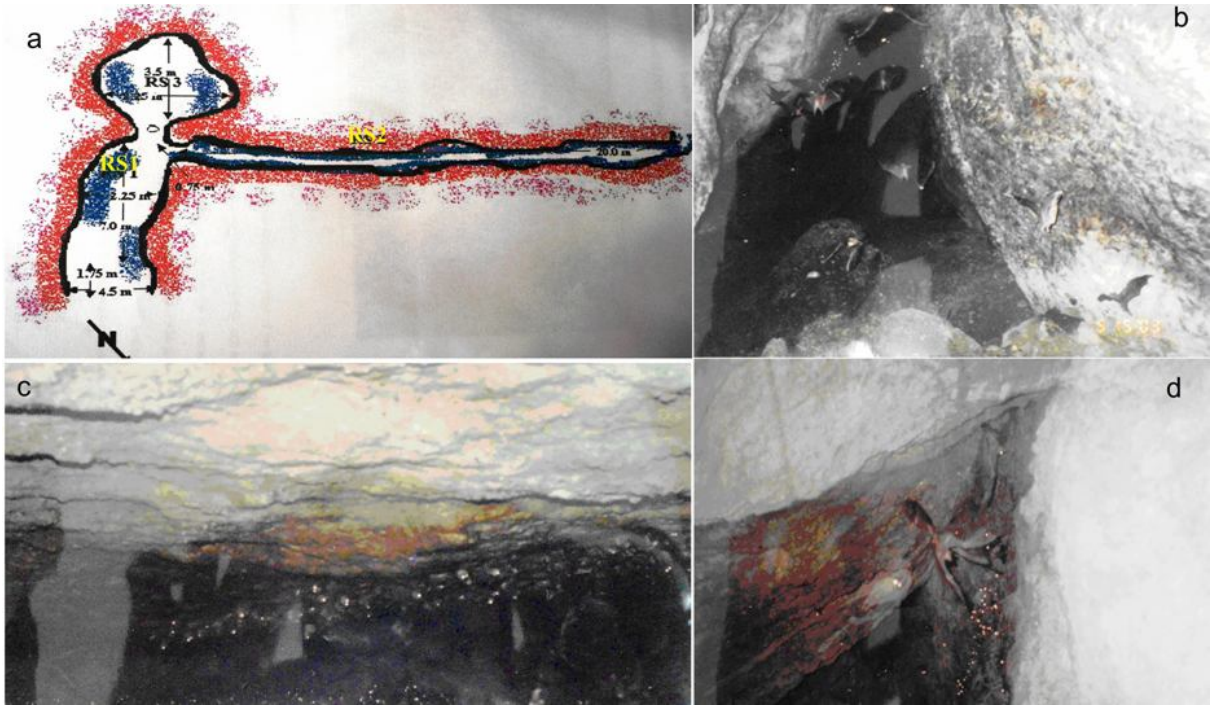


Fig. 3. Malague Cave (a) map of the roosting sites in the cave, (b,c,d) roosting sites inside.

Three non-limestone roosting sites of an estimated total bat population of one thousand to one hundred thousand were observed in the cave. Roosting Site 1 is situated near the mouth of the cave and is 2.25m wide and 7m long. It has a floor to ceiling height ranging from 3 to 4m. Temperature ranges from $28.5^0$C to $28.5^0$C, with a relative humidity of 72%. It is partially illuminated, with the mouth of the cave as the sole source of light. Stalactites and stalagmites were absent although some cracks and crevices were present. No cavities were observed in this area. The roosting bat species were *E. spelaea* and *R. amplexicaudatus.*

Roosting Site 2 has a width of 0.75 m and length of 20m, this tunnel form area is partially illuminated. Is it situated near an exit leading to a cliff. It has a height of 30 to 50 m from the floor to the ceiling. The temperature in this site ranges from $27^0$ C to $28^0$ C with a relative humidity of 72%. Again, no stalagmites or stalactites were seen in this area. No cavities were identified but narrow crevices could be seen. *R. amplexicaudatus* has the largest number of individuals found in the site with an estimated total bat population of 10,000 to 100,000 individuals.

Roosting Site 3 is situated in the innermost portion of the cave and has an area of only 7.875$m^2$. and a floor to ceiling height range of 8-9m with temperature ranging from $27^0$C to $28^0$C and a relative humidity of 73%. This site is characterized by total absence of illumination. Two cavities were present in this site with sizes ranging from 0.40 to 0.60 m wide and 0.15 to 0.25 m deep and a tunnel or hole leading to deeper portion of the cave. Bat species captured in this area were *R. amplexicaudatus* and *E. spelaea.*

Roosting Sites 1 and 2 hold the largest number of bat population inside the cave with an estimate of 500 to 1,000 and 10,000 to 100,000 bats respectively, compared to Roosting Site 3 having only hundreds.

Most of the cave-dwelling bats captured in the cave are *E. spelaea* (Table 1), a species known to roost only in the caves (Heaney et al 2002). Among the several hundreds of *E. spelaea* present, only 48 individual were captured in Roosting Site 1 and most of the individual were mixed adult male and female (Table 1). This cave roosting bat species generally congregate in groups of a few or a dozen to ten thousands (Beck & Lim 1973), which may account for why they were observed to roost in hundreds in Roosting Site 1.

Table 1

Species, sex and age composition of bats in Malague Cave at Buenavista, Agusan del Norte

| *Roosting sites* | *No. of captured individuals* | *Species* | *Sex* | | *Age* | | *Reproductive status adult females* | |
|---|---|---|---|---|---|---|---|---|
| | | | M | F | A | J | L | N-L |
| 1 | 48 | *E. spelaea* | 33 | 15 | 40 | 8 | 1 | 11 |
| | 9 | *R. amplexicaudautus* | 4 | 5 | 6 | 3 | 2 | 1 |
| 2 | 2 | *E. spelaea* | 1 | 1 | 1 | 1 | 0 | 0 |
| | 37 | *R. amplexicaudautus* | 22 | 15 | 23 | 14 | 4 | 5 |
| 3 | 3 | *E. spelaea* | 3 | 0 | 2 | 1 | 0 | 0 |
| | 5 | *R. amplexicaudautus* | 4 | 1 | 4 | 1 | 0 | 0 |

M = Male; F = Female; A = Adult; J = Juvenile; L = Lactating; N-L = Non-Lactating

Another species observed in the cave was *R. amplexicaudatus*, a species which can also be found in Malaysia, Indonesia, Cambodia, Thailand, Vietnam, New Guinea, and Solomon Islands. This bat species is known to roost in caves and found abundant and widespread in agricultural areas up to 500 m (Heaney et al 2010). In the Malague cave, the species was observed roosting on walls of Roosting Sites 2 and 3 but were limitedly observed in Roosting Site 1. Of the nine individuals captured four were males and five females. Among the five females, only two were identified to be lactating. In Roosting Site 2, there were thirty seven individuals of *R. amplexicaudatus* captured, four of which are adult lactating females, while the rest were mixed male and female adults of different bat species.

In Roosting Site 3, only 3 individuals were captured, three of which were *E. spelaea* and five were *R. amplexicaudautus.* These bats were observed to be roosting in cavities, measured 0.40–0.60m wide and 0.15–0.25m deep. It was believed that these bats came from Roosting Sites 1 and 2 after subsequent disturbances were made in those areas. These bats tend to roost in the deeper portion of the cave when they are disturbed. Of the eight bats captured, six individuals were adults and two were juveniles. The cave was disturbed since torches were found and the holes found to be done by treasure hunters.

***Carmen, Agusan del Norte***. There were 42 caves in Carmen, Agusan del Norte, surrounded by coconut trees *(Cocos nucifera)*, some bushes and some noni plants. Almost all the caves in the Vinapor Cave, Carmen, in Agusan del Norte, were disturbed, since they are located on the vicinity of a frequently visited resort. Many other caves still housed a small population of bats and other fauna like snakes and birds. Only three of the caves were described as being composed of coralline limestone, thus were selected.

The mouth of Cave 1 has a width of 6.5m, 1.75m height and 0.75m length, this cave has three openings (Fig. 4). It is located at $09^0$05.6221 N and$125^0$12.5647 E, having an altitude of 13 m above sea level. It is partly muddy or swampy with a shallow body of water at the middle. No guano deposits were observed in the cave. The presence of stalactites and absence of stalagmites were observed and it was partially illuminated. Its air temperature ranges from $26^0$ C to $29^0$ C and with a relative humidity of 90%. The vegetation found outside the cave included banana *(Musa sp.),* papaya *(Carica papaya* L.), coconut *(Cocos sp.)*, noni plant and several kinds of bushes. It was about 10 meters away from the sea and 25 meters away from the resort. It has two roosting sites is a

limestone type cave and has a total mouth area of approximately 4.875 $m^2$. This cave is located about 10 – 15 m away from the sea. Only *T. melanopogon* bat species was observed to roost in this cave.

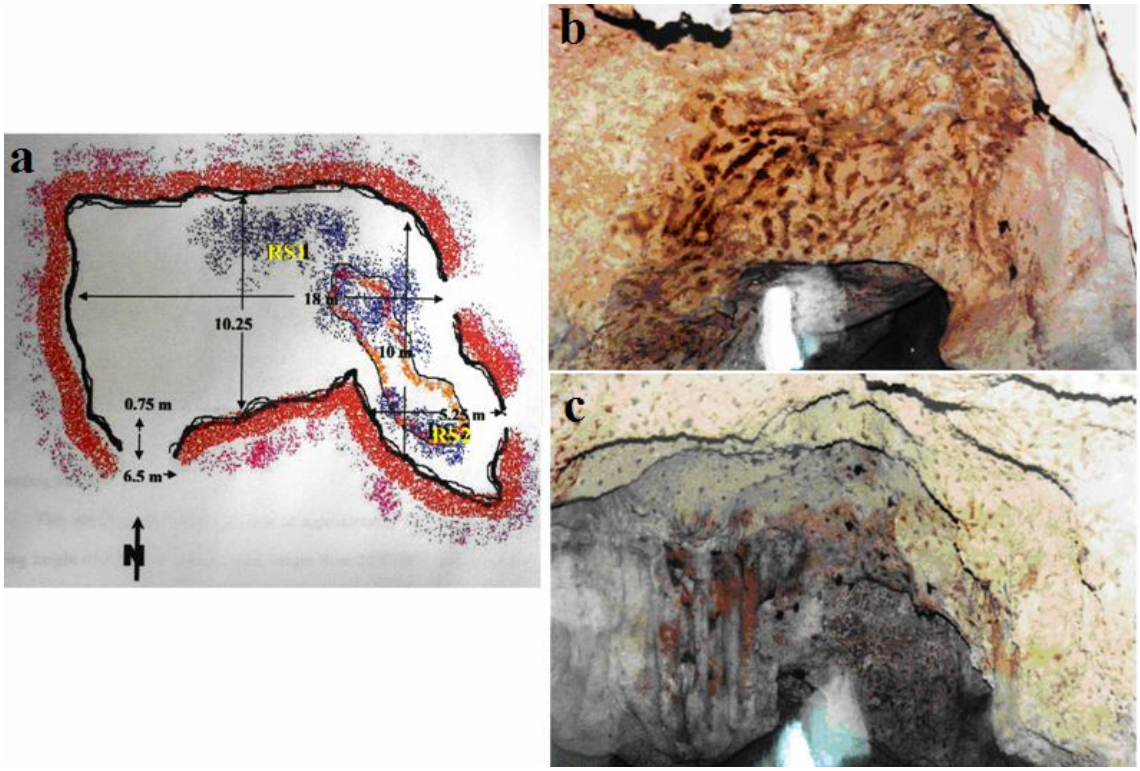


Fig. 4. Cave 1 of Carmen, Agusan del Norte (a) map of the roosting sites in the cave, (b,c) roosting sites inside the cave.

One species was observed in this cave, *Taphozous melanopogon* belonging to *Emballonuridae* family. This bat species was found to roost in groups specifically in crevices and cavities (0.50 to 1.00 m deep) of the cave, where there is partial illumination. Its roosting sites have temperature range of $26^0$C–$29^0$C and relative humidity of 86%-94%. The caught bats have an average body length of 91.77 mm, 19.99 mm tail, 13.05 mm hind foot, 14.99 mm ear length, 60.46 mm forearm and a 21.2 g weight.

Roosting Site 1 has a floor to ceiling height ranging from 3.0 to 4.0 m and a width and length of 10.25 m and 18.0 m respectively. This site is situated near the mouth of the cave. Traces of light from the mouth are observable, making this a partially illuminated area which has a temperature range of $27^0$C - $29^0$C and relative humidity of 86%. An estimated 15 cavities of various sizes can be found in the ceiling of this site and presence of stalactites and absence of stalagmites can be noted.

Roosting Site 2 has a total area of approximately 52.2 $m^2$ and floor to ceiling height of 3.0–4.0 m. Temperature ranges from $26^0$C–$28^0$C and relative humidity is 93%. This cave has stalactites and two partially illuminated exits. There were four cavities of varying sizes observed in the ceiling of the cave. This site is swampy with bodies of water seen at the center. It roosts in groups ranging from 200 to 4000 individuals. Within roost males have been known to form a protective circle around the female and the young. Each male occupies a particular area in the roosting site indicating social hierarchy in the colonies. In some cases there are strictly male or female colonies found in roosts (mainly after the mating season). This bat tends to scream a very piercing high-pitched noise when being captured, in danger or injured (Boonsong & McNeely 1988).

Only *T. melanopogon* was found roosting in the two roosting sites of the cave. The bats were observed clinging to wide cavities of the cave ranging from 0.50 to 1.0 m wide and 0.40–0.60 m deep. Some were also observed roosting in the deeper portion of the cavities and in some cracks and crevices of the cave. Of the captured individuals, many

were adult males and only one lactating female (Table 2). This species was earlier reported in Cebu, Leyte, Ilocos Norte, Nueva Viscaya, Pangasinan, Mindanao, Negros, Palawan, Sibuyan, and Mindoro (Lawrence 1939), commonly observed in urban areas, in areas with limestone caves and in sea caves, at elevations at or below 150 m (Lawrence 1939; Sanborn 1952; Taylor 1934).

Table 2

Species, sex and age composition of bats in Cave 1 at Carmen, Agusan del Norte as observed from May 24 to 26, 2003

| *Roosting sites* | *No. of captured individuals* | *Species* | *Sex* | | *Age* | | *Reproductive status adult females* | |
|---|---|---|---|---|---|---|---|---|
| | | | M | F | A | J | L | N-L |
| 1 | 27 | *T. melanopogon* | 18 | 9 | 26 | 1 | 1 | 8 |
| 2 | 8 | *T. melanopogon* | 5 | 3 | 8 | 0 | 0 | 3 |

M = Male; F = Female; A = Adult; J = Juvenile; L = Lactating; N-L = Non-Lactating.

Cave 2 is located $09^0$05.5753 N, $125^0$12.7234 E and is 11 m above sea level. This is the largest among the three caves described. It has one opening measuring 13m wide, 6.75m long and 4m high. The entire cave was almost entirely illuminated, with stalactite and stalagmites and a moist sandy substrate. Some large shells are found fossilized in the walls of the cave. The air temperature of the cave ranged between $25^0$C to $28^0$C, with an average relative humidity of 93%. This cave is of limestone type with two roosting sites identified (Fig. 5). It was utilized by only two species of bats, *R. amplexicaudautus* and *T. melanopogon*. Swiftlets can also be seen inhabiting this cave together with some small amphibians. Two roosting sites were observed in this cave one of which is larger, located near the mouth of the cave (RS1). This roosting site has a length of 17.0 m, a width of 13.5 m and a floor to ceiling height of approximately 10.0 m. This site has a temperature range of $26^0$C–$28^0$C and a relative humidity of 93% and is properly illuminated due to the source of light coming from the wide opening of the cave entrance.

Most individuals captured in Roosting Site 1 belong to *T. melanopogon.* A maternal colony was also observed occupying a cavity in the site. Based on the individuals captured most of the adult female bats were lactating and were carrying a neonate. Only three individuals of *R. amplexicaudautus* were captured and observed in Roosting Site 1 and the rest were *T. melanopogon* (Table 3). One of the three individuals of *R. amplexicaudatus* was an adult pregnant female and the remaining two were adult males. It was observed that one *R. amplexicaudatus* roosted along side with groups of *T. melanopogon* on wide cavities while the other individual roosted alone on another cavity.

Roosting Site (2) (Fig. 6) has an average floor to ceiling height of 3.75 m and has an approximate area of 94.0 $m^2$. Stalagmites and stalactites characterize this site with at least 19 cavities of various sizes. Temperature range is $25^0$C to $27^0$C, the relative humidity of 93% and is partially illuminated. Only *T. melanopogon* was observed in this roosting site.

Only a total of eight bats were captured in Roosting Site 2, five of which were males and three were lactating females. The females were observed roosting together with the male bats in crevices and small cracks.

Cave 3 (Fig. 6) is a frequently visited cave located at $09^0$05.4952 N, $25^0$12.7806 E and is 24 m above sea level within the vicinity of a beach resort. With 1.25 m height, 0.75 m width, and 3.75 m height, this cave is partially illuminated by three openings, two that open to the sea and one used as an entrance to the interior by using a ladder. The substrate in this cave consists of dry to rocky soil. Air temperature ranged between $27^0$C to $29^0$C and the relative humidity is 86%.

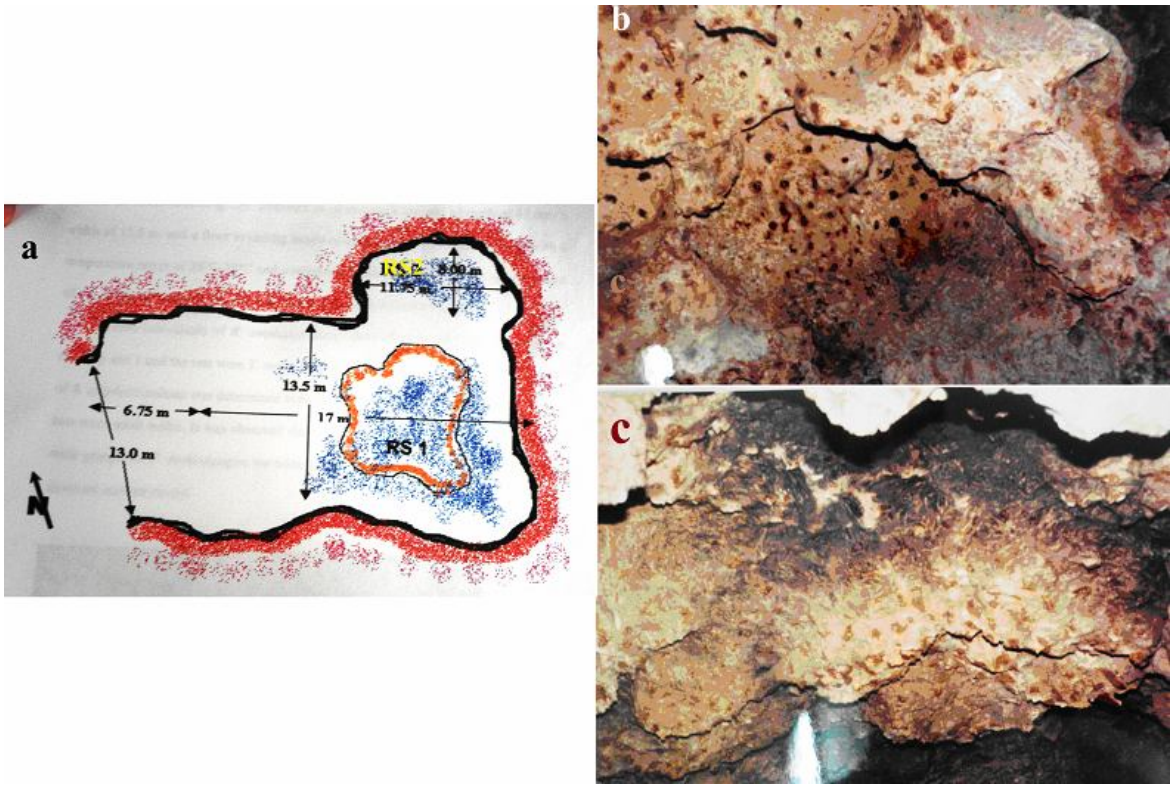


Fig. 5. Cave 2 of Carmen, Agusan del Norte (a) map of the roosting sites in the cave, (b, c) roosting sites inside the cave.

Table 3

Species, sex and age composition of bats in Cave 1 at Carmen, Agusan del Norte as observed from May 24 – 26, 2003

| *Roosting sites* | *No. of captured individuals* | *Species* | *Sex* | | *Age* | | *Reproductive status adult females* | |
|---|---|---|---|---|---|---|---|---|
| | | | M | F | A | J | L | N-L |
| 1 | 30 | *T. melanopogon* | 18 | 12 | 29 | 1 | 7 | 4 |
| | 3 | *R. amplexicaudatus* | 2 | 1 | 3 | 0 | 0 | 1 |
| 2 | 8 | *T. melanopogon* | 5 | 3 | 8 | 0 | 3 | 0 |

M = Male; F = Female; A = Adult; J = Juvenile; L = Lactating; N-L = Non-Lactating.

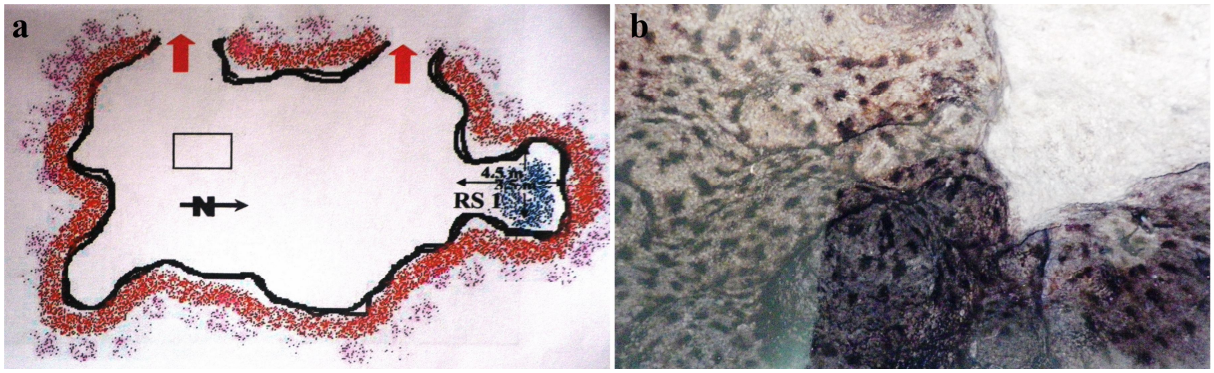


Fig. 6. Cave 3 of Carmen, Agusan del Norte (a) map of the roosting sites in the cave, (b) roosting site inside the cave.

Cave 3 is a disturbed limestone cave. People frequently visit it using a steel ladder to be able to enter the interior of the cave. This cave has two exists which both lead to the open sea. Only one roosting site was identified in this cave. Swiftlets were also found

inside the cave. There is only one roosting site, characterized by width and height of 3.5m and 4.5m, respectively, and a floor to ceiling height of 2.0–3.0m. Only stalactites were seen on this site with at least 3 cavities of 0.50 m wide and 0.30m deep. Temperature ranged from $27^0$C to $29^0$C and has a relative humidity of 86%.

An estimate of 10–15 *T. melanopogon* individuals was found to occupy this site. Only eleven individuals were successfully captured, one of which was an adult non-lactating female while others were adult males. The relatively smaller population of bats in this area was attributed to the disturbances made by the people visiting the beach resort. Burnt bamboo sticks, trash and bottles were observed inside the cave. Traces of vandalism were found everywhere on the walls of the cave. Even though, it was observed that these bats still roost in the area.

***RTR, Agusan del Norte***. There are two caves identified in this small village of Brgy, Humilog of RTR, Agusan del Norte. One cave is about 80 m from the village and the other is 200 m away, which could be reached through a canoe. Only one limestone cave, the Humilog cave, located $09^0$03.1473 N and $125^0$33.6249 E, 51m above sea level, was selected and described. This cave has an average temperature of $26^0$ C and an average relative humidity of 86%. It is located 50 m away from the estuary. With partial illumination to dimly lit degree of illumination, this two-chambered cave has an opening of 1.25 m length, 1.0 m width and a 0.75 m height. This cave is surrounded with pineapples *(Anacardium iccidentale),* coconut trees *(Cocos nucifera),* bamboo trees, *Ficus sp.*, and some unidentified plants. Bottles used as torchlight found in the interior of the cave indicate it is disturbed.

Two roosting sites were identified in this cave with a hole or tunnel in the second roosting site leading underground (Fig. 7). Roosting Site 1 has an area approximately 11.25 $m^2$ and a floor to ceiling height of about 2.0–3.0 m, this roosting site is situated near the mouth of the cave. Temperature ranged between $25^0$ C – $27^0$ C and the humidity was 86%. This area is characterized by partial illumination. A stalactite, stalagmites, several cavities and some crevices are present in this roosting site.

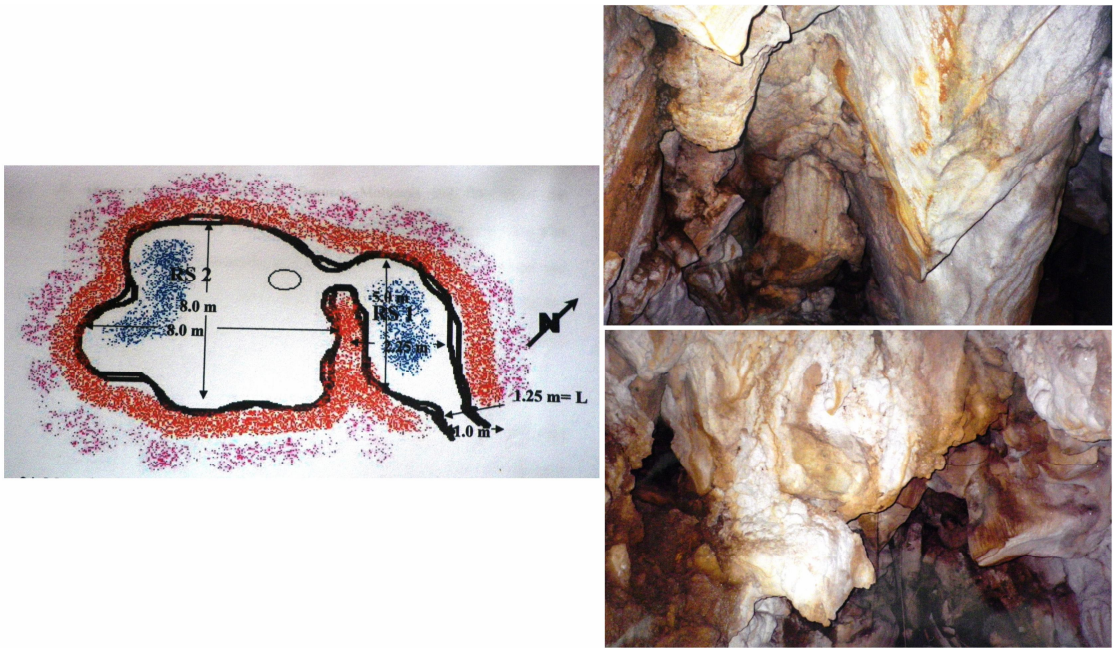


Fig. 7. Cave 1 of RTR, Agusan del Norte (a) map of the roosting sites in the cave, (b, c) roosting sites inside the cave.

Only two species of bats were identified to roost in Roosting Site 1 and these were *E. alecto* and *R. subrufus.* Of the two species, *A. alecto* is a bat species that can be found in caves or near forests not only in the Philippines but also of Sulawesi, Borneo, Moluccas and throughout the Philippines (Heaney 1991). Only two individuals, one male juvenile

and non-lactating adult female were identified and successfully captured in this site (Table 4) occupying singly in cavities.

Table 4

Species, sex and age composition of bats in Cave 1 at RTR, Agusan del Norte as observed from May 24 to 26, 2003

| *Roosting Sites* | *No. of captured individuals* | *Species* | *Sex* | | *Age* | | *Reproductive status adult females* | |
|---|---|---|---|---|---|---|---|---|
| | | | M | F | A | J | L | N-L |
| 1 | 3 | *R. subrufus* | 2 | 1 | 3 | 0 | 0 | 1 |
| | 2 | *E. alecto* | 1 | 1 | 1 | 1 | 0 | 1 |
| 2 | 2 | *R. subrufus* | 2 | 0 | 2 | 0 | 0 | 0 |

M = Male; F = Female; A = Adult; J = Juvenile; L = Lactating; N-L = Non-Lactating.

*R. subrufus* observed in this study is considered endemic to the Philippines, reported in the provinces of Camiguin, Catanduanes, Abra, Camarines Sur, Isabela, Laguna, Pampanga, Rizal, Sorsogon, Davao del Sur, South Cotabato and Mindoro (Heaney 1991). The habitats of this species are poorly known, some observations being recorded near sea level, other to over 1000 m, while some recorded in caves. Of the captured individuals of *R. subrufus,* two were male adults and one non-lactating adult female.

For Roosting Site 2, it was observed to have an estimated area of 16.0 $m^2$ with a floor to ceiling height of about 4.5–6.5m, temperature ranging between $24^0$C to $27^0$C and a relative humidity of 85%. This site was located in the inner portion of the cave, with small opening at the ceiling, making the site partially illuminated. Stalactites and stalagmites were also seen in the site. A hole or an opening was also seen leading to the deeper portion of the cave.

The results of the study show that the illumination of the cave, limestone type or not, size of reliefs, height of ceiling, including human disturbances, affect the roosting preferences of the identified cave-dwelling bats. Most bats roost in caves with higher ceiling and with partial illumination like caves in Buenavista and Carmen to avoid disturbances or threats inside the caves. The partial illumination preference of bats indicates that roosting should be near an exit for easy access or escape from the cave when threatened or disturbed.

Three species prefer to roost in a limestone type of caves in Carmen and RTR towns of Agusan del Norte. Only *E. spelaea* and *R. amplexicaudatus* were observed to roost in non-limestone type of cave in Buenavista. This observation is in contrast with the observations made by Garcia (2003) where *E. spelaea* and *R. amplexicaudatus* prefer to roost in a limestone cave. Disturbances made in the caves, like treasure hunting, have affected the population of the bats. Those with disturbances gave few or no bats roosting. Those few observed bats presumably migrated from other caves and those with no bats observed could be due to the migration of the bats into other undisturbed caves. This implies that some bats tend to migrate to other caves when threatened and disturbed.

The roosting preferences of bats are also affected by their reproductive activity. Lactating female *T. melanopogon* together with neonates were observed to roost in groups and in cavities inside these cave. Temperature and relative humidity however have no patterns associated in the roosting site selection of bats. Other studies have shown that only the nursery colonies prefer relatively high temperatures for the growth and development of the young (Dwyer 1971).

This study is however far from complete. Since bats spend a considerable part of their life roosting and roost characteristics have important implications for survival and reproductive success (Kunz 1982), detailed studies on their roost location, structure and aspect should be investigated since these determine microclimatic conditions which may influence the energetic costs of key stages of their life cycle such as hibernation (Humphries et al 2002), pregnancy and lactation (Sedgeley 2001; Kerth et al 2001; Chruszcz & Barclay 2002). Likewise, the characteristics of the roosting environment also

influence exposure to predators (Vonhof & Barclay 1996; Rydell et al 1996), parasite load (Lewis 1996), social behaviour (Wilkinson 1985; Willis & Brigham 2004), and the cost of commuting to preferred foraging sites (Brigham 1991; Jaberg & Blant 2003) thus should be further studied. Furthermore, bats exhibit selection in roost choice, showing preferences linked with their ecological requirements, which differ among species, seasons (Kunz 1982; Kunz & Lumsden 2003) and geographical areas (Rodrigues et al 2003). Since the Philippines is basically archipelagic, further spatial and temporal surveys on the daytime roosting preferences of bats in other sites within and between species and populations should be done.

**Conclusions**. Results of the study have shown that the diurnal roosting preferences of five observed species of bats inside selective caves in Agusan del Norte, Philippines vary. *Emballonura alecto* preferred to roost in small cavities with partial illumination while *Rhinolophus subrufus* roost in partially illuminated to dimly lit areas. Most individuals of these two species preferred to hang singly in ceilings and cavities of lower height. On the other hand, *Taphozous melanopogon* roost in cavities, cracks and crevices with partial illumination. *Eonycteris spelaea* and *Rousettus amplexicaudatus* cling on walls on areas where there is partial illumination. In general, illumination, cave size, reliefs and height of roosting sites, reproductive activities, limestone type and the degree of disturbance played significant roles in the diurnal roosting preferences of the five observed species of bats.

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