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Microhabitats of Cave Crickets in Agusan del Sur, Philippines

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ABSTRACT
This study was conducted to determine the microhabitats of cave crickets in eight caves in Agusan del Sur. Collection was done on June 22-July 10, 2015. Using hand searching method, cave crickets were collected and observed in different microhabitats. Eleven microhabitats were identified in two different zones. Walls and ceilings in the twilight zone of the cave were the most utilized microhabitats by the four genera of crickets. Walls in the twilight zones had the highest species richness and abundance of cave crickets. Macropathus was the most abundant genus of the four genera of crickets documented in the caves. It was mostly found in the deep zone. Guano deposits appear to influence cricket abundance. Results indicate that microhabitats play a role in the species richness and abundance of cave crickets
Keywords: *crevices, deep zone, guano, Macropathus, twilight zone.*

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INTRODUCTION

Crickets are hemimetabolous and oviparous insects and an important component of forest litter macrofauna [1]. In the field, most of the crickets are omnivorous feeding on organic materials as well as decaying plant material, fungi, and seedling plants [2]. Crickets are also known to eat other dead crickets and become predator to weak members of their own species when there is no available food [2]. All crickets reproduce sexually. Most crickets use calling songs in sexual pair formation [3]. They mate and lay eggs in the soil in the late summer before succumbing to old age or freezing temperatures [4].

Cave crickets, also known as camel crickets and spider crickets because the back is humped up with the head bent down [5] belong to the Family Rhaphidophoridae. All Rhaphidophoridae species are nocturnal and wingless with a preference for humid habitats [6]. Rhaphidophoridae has nine subfamilies that are mainly distributed in the temperate regions of the northern and southern hemispheres and in the Southeast Asian tropics [6]. Cave crickets that feed outside and roost in caves are important in the food budgets of cave ecosystems [7].

Cave crickets gather around entrances as roosts and in staging areas where they can evaluate surface conditions before leaving the cave to forage but in accordance with the time of day and season. They can also be found in stable deep cave areas away from human-sized entrances, but close to cricket-sized entrances [5]. Cave crickets exhibit various modifications and adaptations to the cave environment [8]. Adaptations such as antennae and femora aid them to stride on uneven surfaces in total darkness inside the cave [5]. Body coloration and reduced eye pigmentation may also vary in some cave crickets [9]. Both females and males have two cerci at the end of the abdomen that are rich in sensory receptor [5].

Cave crickets are also extremely sensitive to temperatures above cave temperatures, and show markedly greater metabolic demands with modest increases in ambient temperature compared to camel crickets [10]. When the environment of cave crickets becomes too hot or dry, they may move inside. They are not usually capable of reproducing outside of their outdoor habitats and rarely find indoor locations that are dark and damp enough to suit them. In addition, understanding the role that each species plays within cave communities is a key for the management and protection of endangered karst invertebrates [11].

Many biodiversity studies have been reported in the Philippines but only few studies on caves and cave fauna were conducted. Recent study on crickets was conducted by Lagare and Nuñeza [12] in selected caves while an earlier study of Baser [13] reported on cave crickets in selected caves in Northern Mindanao.

This study aimed to determine the microhabitats of crickets in caves and identify existing and potential threats to the caves they inhabit.

METHODOLOGY

Sampling Area

Agusan del Sur is a landlocked province of the Philippines located in the Caraga region in Mindanao. Sampling areas were established in three municipalities and one city with caves (Figure 1). This province has a total land area of 8966 square kilometers (km^2) with the coordinates 8.5000° N, 125.8333° E. Forestland constitutes 76% of the total land area or 6,827.5 km^2 while the alienable and disposable land constitutes about 24% or 2,137.5 km^2 . Present land use, however, showed that settlements and commercial areas already occupy some of the forestlands. However, the province has lost so much of its forest resources because of existing industries which are extractive in nature.

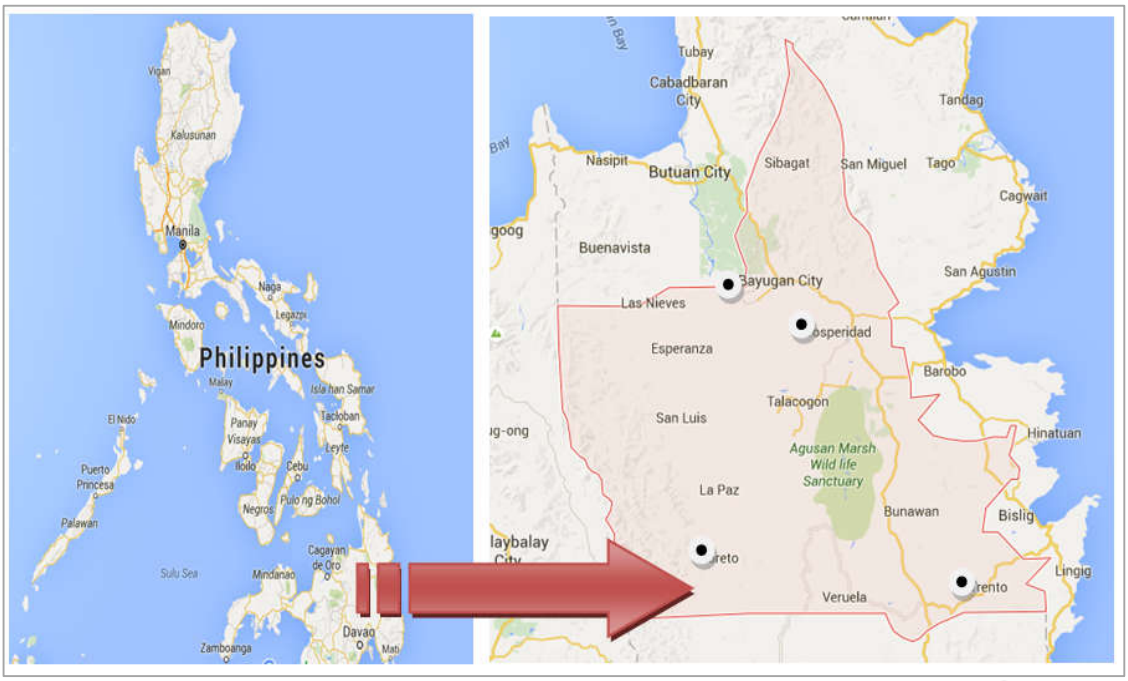

Figure 1. Location of Agusan del Sur showing the municipalities and city with cave areas ( ) [14].

Cave sites

Wilderness Cave

This cave in Barangay Mt. Carmel, Bayugan has three floors. It is situated at 8°28'20.38'' North and 125°50'51.4'' East on the first floor and 8°48'22.7'' North and 125°50'58.7'' East on the second floor. It has an elevation of 733 meters above sea level (masl) at the first floor and 687masl at the second floor. The first floor has an entrance (1.5ft by 50cm dimension) not easily accessible due to a vertical orientation with a 60 degrees slope while the second floor has an entrance (2ft by 1m dimension) also not easily accessible due to a vertical orientation with a 10 degrees slope. The third floor has an entrance (2m by 1.5m dimension) not easily accessible due to a vertical orientation with a 60 degrees slope. The first floor has three chambers, second floor has two chambers, and the third floor has only one chamber. A body of water was observed in the first and second floors. Guano material is present in all floors. Few stalagmites and stalactites are present on the first floor, moderate stalactites and few stalagmites on the second floor, and few stalactites and absence of stalagmites on the third floor. The twilight zone of the first and second floors has a loamy substrate while the deep zone has a sandy substrate. The third floor has a loam substrate. First floor has a temperature of 24°C in the twilight zone, 23°C in the deep zone and a relative humidity of 92%. The second floor has a temperature of 24.5°C in the twilight zone, 23°C in the deep zone and a relative humidity of 92 %. Third floor has a temperature of 24°C in the twilight zone, 24°C in the deep zone, and a relative humidity of 92%. Surrounding the cave is a secondary type of vegetation. Canopy epiphytes, vines, and understory plants (shrubs and ferns) were present outside the cave. Vandalism, holes for treasure hunting activity, and cutting of stalactites were indicative of disturbance inside the cave.

Magdaguhong Cave

This cave in Barangay Mt. Carmel, Bayugan is situated at 8°47'42.9'' North and 125°50'26.4'' East at an elevation of 569masl. It has a main entrance (10m by 10-15m dimension) which is easily accessible with a horizontal orientation and flat slope. The cave has three chambers with a temperature of 24.5˚C in the twilight zone, 24˚C in the deep zone, and 92% humidity. Outside the cave is a deciduous type of vegetation. Canopy epiphytes were absent. Canopy vines and understory plants (shrubs and ferns) were present. Inside the cave is a loamy soil substrate. Guano material was absent. Stalactites were abundant. Stalagmites, column, crystal lining, and flowstones were present but very few. Vandalism and cutting of stalactites were observed to be indicative of disturbance.

Ararat Cave

This cave in Barangay Mt. Ararat, Bayugan is situated at 8°49'43.1'' N and 125°50'15.3'' East. It is located at an elevation of 693 masl. It has an entrance (10m by 10-15m dimension) not easily accessible due to a vertical orientation with 80 degrees slope. The cave has two chambers with a temperature of 24.23°C in the twilight zone, 22°C in the deep zone, and 92% humidity in the twilight zone. It has a secondary type of vegetation. Canopy epiphytes, vines, and understory plants (shrubs and ferns) were present outside the cave. Inside the cave is a loamy soil substrate. Guano material was absent. Stalactites and stalagmites were abundant. The cave has moderate presence of column and crystal lining. Flowstones were present but very few. Cutting of stalactites was indicative of disturbance.

Katam-isan Cave

This cave in Barangay Mt. Ararat, Bayugan is situated at 8°49'38.2'' North and 125°50'9.2''East at an elevation of 598masl. It has an entrance (50cm by 1m dimension) not easily accessible due to a vertical orientation with a 30 degrees slope. The cave has three chambers with a temperature of 25˚C in the twilight zone, 24˚C in the deep zone, and 92% humidity in the twilight zone. Outside the cave is a secondary vegetation type. Canopy epiphytes, vines, and understory plants (shrubs and ferns) were present. Inside the cave is a loamy soil substrate. Guano material was absent. It has a stream in the deep zone. Stalactites and crystal lining were abundant. The cave has moderate stalagmites. Column and flowstones were present but very few. Cutting of stalactites was indicative of disturbance.

Agpan Cave

This cave in Barangay Manat, Trento is situated at 8˚07'17.5'' North and 126˚06'08.5'' East at 83masl. It has five openings which are easily accessible. Both the first opening (75m by 50m dimension) and second opening (10m x 15 m dimension) have 10 degrees slope. The third opening (50m by 30m dimension) is 45 degrees sloping. The fourth opening (10m by 15m dimension) and the fifth opening (10m by 5m dimension) have 10 degrees slope. The cave has seven to eight chambers with a temperature of 25.5˚C in the twilight zone, 24˚C in the deep zone, and 92% humidity at the twilight zone and 85% at the deep zone. Outside the cave is a secondary type of vegetation. Canopy epiphytes, vines, and understory plants (shrubs and ferns) were present. Inside the cave is a loamy soil substrate in the twilight zone but sandy at the upper portion due to soil erosion brought by Typhoon "Senyang". Guano material was present around one foot in thickness. The cave has a stream in one chamber. Stalactites were abundant. Stalagmites, column, and crystal lining were present but very few. It has moderate stalagmites. Column and flowstones were present but very few. Flowstones were absent. Guano harvesting and soil erosion due to typhoon "Senyang" were indicative of disturbance.

Tao-Naga Cave

This cave in Barangay Magsaysay, Prosperidad is situated at 8°2'33.4'' North and 126°3'45.7'' East at an elevation of 63 masl. It has two openings with main entrance, easily accessible, of 2m by 5m dimension and a flat slope. The second opening, 0.75m by 15m dimension is sloping. The cave has three chambers with a temperature of 25.5˚C at the twilight zone, 24.5˚C at the deep zone, and 92% humidity in the twilight zone and 85% in the deep zone. Outside the cave is a secondary type of vegetation. Canopy epiphytes were absent. Canopy vines and understory plants (shrubs and ferns) were present. Inside the cave is a sandy soil substrate with small rocks. Guano material was present. The cave has a stream. Stalactites and crystal lining were abundant. The cave has moderate stalagmites and flowstones. Columns were present but very few. This cave is utilized as a treasure-hunting area.

Simbahan Cave

This cave in Barangay Waloe, Loreto is situated at 8°9'25.3'' N and 125°40'26.3'' East at an elevation of 63 masl. It has two openings with main entrance of 6m by 4m dimension, not easily accessible due to a vertical orientation with a 30 degrees slope. The second opening is flat, easily accessible, of 2mm by 1.5m dimension. The cave has four to six chambers with a temperature of 27˚C in the twilight zone, 26˚C in the deep zone, and 78% humidity at the deep zone. Outside the cave is a secondary type of vegetation. Canopy epiphytes, vines, and understory plants (shrubs and ferns) were present. Inside the cave is a loamy soil substrate. Guano material was present but very few. Stalagmites, columns, and flowstones were present

but very few. Stalactites were moderate in abundance. Crystal lining was absent. This cave is utilized as a treasure- hunting area.

Sampyagit Cave

This cave in Barangay Waloe, Loreto is situated at 8°9'16.7'' N and 125°41'26.6''East at an elevation of 99 masl. It has a vertically- oriented opening of 4m by 1.5m dimension. The cave has five to six chambers with a temperature of 26˚C in the twilight zone, 25˚C in the deep zone, and 78% humidity in the deep zone. Outside the cave is a secondary type of vegetation. Canopy epiphytes, vines, and understory plants (shrubs and ferns) were present. Inside the cave is a loamy soil substrate. Guano material was present but very few. The cave has two main chambers, left and right. Stalactites, stalagmites, crystal lining, and flowstones were present but very few and columns were absent in the left chamber. Stalactites were abundant, stalagmites and column were present but very few in the right chamber. Crystal lining and flowstones were absent in the right chamber. This cave is utilized as a treasure -hunting area.

Sampling methods

Field sampling was conducted on June 22-July 10, 2015 in eight cave sites of the municipalities of Trento, Prosperidad, and Loreto, and city of Bayugan in Agusan del Sur. Specimens were collected using hand searching and direct counting techniques. Hand searching is the most preferable method used for cave cricket sampling. Possible microhabitats like cave walls and floor were searched.

Samples were placed in separate plastic bags. Representative samples which were taken as voucher specimens were transferred to plastic cups which contain 70% ethanol and air-dried for about 2-3 hours. After air-drying, crickets were mounted by pinning the middle of their thorax and placed in a box. Naphthalene balls were placed in the box to avoid entry of other insects that can possibly damage the specimens. Samples collected were identified by pictorial keys and verified by an expert.

Observation of Existing Threats

Human disturbances inside the cave were observed Existing threats in each cave site were also noted. The local guides were interviewed regarding the threats to the cave.

Data analysis

Data analysis was done using Paleontological Statistics software (PAST) package version 2.17c [15] for seriation and biodiversity indices.

RESULTS AND DISCUSSION

Microhabitats

Table 1 shows the 11 microhabitats of cave crickets in Agusan del Sur. Walls in the twilight zone were the most preferred microhabitat of cave. crickets The four genera: *Endacusta*, *Macropathus*, *Pteronemobius* and *Ceuthophilus* were found in this microhabitat. The walls in the deep zone showed greater number of individuals but are less diverse. *Endacusta* was observed in the twilight zone areas only where some individuals were found in cave entrances where dry walls and crevices are present. This genus was observed to occur when other genera like *Macropathus* and *Ceuthophilus* were absent or less in number. Individuals of *Endacusta* were also observed by Lagare and Nuñeza [12] roosting on dry cave walls in Blue Water Cave of Northern Mindanao. *Pteronemobius* is a field, ground, and tree cricket which belongs to Gryllidae family. This genus was found in Wilderness cave (first floor) on the wall near the cave entrance which has a great number of shrubs, ferns, canopy epiphytes and vines just outside the cave. The same finding was observed in the study conducted by Lagare and Nuñeza [12] that *Pteronemobius* sp. was found exactly at the cave entrance in Gitagum Cave 1 of Northern Mindanao where vegetation and low canopy cover was abundant. The least number of crickets was recorded in rocks in both twilight and deep zone areas where only one genus was documented. Rocks were absent in some cave sites. Great number of *Macropathus* and *Ceuthophilus* were observed in Agpan cave where guano deposits were abundant and accumulated on the muddy soil surface thus providing more supply of food and supporting more crickets. Lagara and Nuñeza [12] and Novises and Nuñeza [16] also found that *Macropathus sp.* and *Ceuthophilus sp.* were the most abundant crickets associated with guano deposits. The high humidity of Agpan cave and the presence of guano support a high population density of cave crickets [17]. Rotten logs were observed in some cave sites like Wilderness cave (2nd floor) where housing and clothing remnants were observed. According to the local people, the said cave was used as shelter during the 1990's when the cave accommodated 40 families. The mottled coloration of *Macropathus* and *Ceuthophilus* was noticed in crevices in deep zone areas. Some individuals of these genera were observed to be roosting together with the spiders.

Table 1: Microhabitats of Cave Crickets in Selected Areas in Agusan del Sur.

Microhabitats	No of individuals	No. of genera Observed	Shannon (H')	Evenness (E)
Rotten logs (TZ)	2	2	0.6931	1
Rocks (TZ)	1	1	0	1
Walls (TZ)	8	4	1.266	0.8865
Crevices (TZ)	3	2	0.6365	0.9449
Ceilings (TZ)	5	3	1.055	0.9572
Rotten logs (DZ)	5	2	0.5004	0.8247
Guano (DZ)	7	2	0.4101	0.7535
Rocks (DZ)	1	1	0	1
Walls (DZ)	10	2	0.6172	0.9269
Crevices (DZ)	7	2	0.4101	0.7535
Ceilings (DZ)	8	2	0.3768	0.7288

Legend: TZ- Twilight zone, DZ- Deep zone

There were seven microhabitats observed to have similar number of genera in different zones: rotten logs in twilight and deep zones, crevices in twilight and deep zones, and guano, walls and ceilings in deep zone areas. The difference in number of individuals of each genus among the sampled microhabitats showed the effect of variation in habitat tolerance of each genus, therefore also associated with the availability of specific habitat to thrive in.

The walls and ceilings in the twilight zone exhibited moderate diversity. The rest of the microhabitats had low diversity. Lagare and Nuñeza [12] reported similar results wherein most of the genera were observed in cave walls and others were found roosting on high walls about two meters above the cave surface in the twilight and inner cave zones. Most of these crickets were observed approximately 20 meters away from the cave entrance and in the inner recess zone. Novises and Nuñeza [16] also found that most of the crickets species documented prefer the walls of twilight zone of the cave as well as the inner zone.

Evenness values show how equally distributed the individuals of a species are in a microhabitat, with values near 1.0 indicating well distributed species [18]. All the microhabitats showed more or less even distribution which means that no single genus dominates a particular microhabitat. Enriquez and Nuñeza [19] also added that the distribution of organisms involves selection of habitats that provide the resources required for the survival of individuals of a particular species.

Microhabitat Preferences

Seriation analysis showed that cave crickets are more diverse on the walls in the twilight zone than in the deep zone (Table 2). However, *Ceuthophilus* and *Macropathus* are present in all zone areas. According to Lavoie *et al.* [5], when these species roost they gather around cave entrances in staging areas where they can evaluate surface conditions before leaving the cave to forage for food. *Endacusta* prefers to roost on dry walls and crevices where there is illumination or twilight zone [12] that is why it was absent in deep zone areas and some caves which have a stream inside the cave. Broken stalagmites and stalactites were observed in some cave sites like Katam-isan cave. This cave site was noticed to have the least number of crickets. This condition might have affected the roosting crickets. The absence or very low number of cave crickets may be due to the absence of guano materials and presence of human disturbances in the form of stalactite and stalagmite collection that may have disturbed the floor and wall microhabitats of crickets. The study of Lagare and Nuñeza [12] found that extensively disturbed caves have least number of crickets and the more guano deposits, the more number of crickets, and thus cave areas without guano deposits have less number of crickets. Furthermore, Taylor *et al.* [11] found that low number of cricket reflects elevated levels of human disturbance and probably a reduction in food input (natural litter input, cricket guano).

Table 2: Seriation analysis of four genera of cave crickets with respect to their cave zone microhabitats.

Scientific Name	Cave Zones					
	Twilight Zone			Deep Zone		
	Floor	Walls	Ceilings	Floor	Walls	Ceilings
Endacusta		■	■			
Pteronemobius		■		■		
Ceuthophilus	■	■	■	■	■	■
Macropathus	■	■	■	■	■	■

Results were similar to that of Lagare and Nuñeza [12] wherein *Macropathus* was observed to be abundant and widely distributed. Lavoie *et al.* [5] assumed that weather effects are directly seen on the guano communities because weather causes changes to the cricket's foraging activity, guano deposition, and even survival of crickets. During sampling, the weather was unfavorable in other cave sites like Wilderness cave (all floors) and Magdaguhong cave. These cave sites had low number of crickets. It appears that poor weather conditions negatively affect the roosting and foraging activities of crickets.
Macropathus and *Ceuthophilus* were the most abundant crickets observed in all cave microhabitats (Table 3). All species were present on the walls of twilight zone indicating that the low temperature, high humidity, and the availability of food in this zone could contribute to the presence of crickets. Studier *et al.* [20] reported that crickets cannot metabolically regulate their body temperature, so body temperature changes in changing environmental temperature thus explaining why there were few crickets found at high temperature and low relative humidity. The study of Novises and Nuñeza [16] also found that the most preferred microhabitat of cave crickets is the wall of the twilight zone which could be due to high humidity and abundant food (guano) deposit. Out of 11 microhabitats, walls in the twilight zone are the only microhabitat where all the four genera are found. Only *Ceuthophilus* and *Macropathus* were recorded in rock microhabitats. Ceilings in deep zone microhabitat had two genera present, namely: *Macropathus,* and *Ceuthophilus. Pteronemobius* was observed only on walls in the twilight zone.

Table 3: Seriation analysis of cave cricket microhabitats within the cave zones.

Scientific Name	Microhabitats										
	Floors					Walls				Ceilings	
	Twilight zone		Deep zone			Twilight zone		Deep zone		Twilight zone	Deep zone
	A	B	A	B	C	D	E	D	E	F	F
Pteronemobius						■					
Endacusta						■	■			■	
Ceuthophilus	■	■	■		■	■	■	■	■	■	■
Macropathus	■		■	■	■	■		■	■	■	■

Legend:A- Rotten logs, B- Rocks, C- Guano, D-Walls, E-Crevices, F-Ceilings

Macropathus and *Ceuthophilus* were observed jumping on the walls of the caves. Some of them were found in the holes of cave walls together with spiders and roosting on high walls. Enriquez and Nuñeza [19] reported that more cave crickets are found when there are many spiders. Agpan cave has abundant number of *Macropathus.* This cave was also observed to have thick guano deposit of about one foot thick. Northup *et al*. [21] reported that the food of these crickets often consists of bat guano and essentially identical to its crop content. Thus, more guano indicates more source of food. According to Richards [22], this genus has a wide range of habitat compared to other species as long as there is a high humidity and various percentage of illumination.

Rotten logs in twilight and deep zones, guano, walls, crevices, and ceilings in deep zone microhabitats shared the most similar cricket genera composition. Cave crickets utilize these types of microhabitats as roosting sites. The two genera common to these microhabitats are *Macropathus* and *Ceuthophilus.* Some crickets were found in the holes. These genera commonly complete their life cycle in caves but not restricted to this habitat. They usually occupy separate ecological niches [8].

Threats to cave crickets

Caves are considered as one of the most fragile habitats and unusual home to a variety of organisms including crickets. However, common threats were observed such as extensive vandalism, treasure hunting, and use of the cave as recreational area. Katam-isan cave has extensive degree of disturbance. Broken stalagmites and stalactites were observed. It was believed that locals cut them to sell. Some broken bottles and plastic wrappers were left inside the cave indicating that caves are used for unregulated recreational activities. The cave opening also hinders the entrance of bats and birds due to the installation of grills. However, these grills were installed for the purpose of preventing people to enter the caves. Extensive vandalism and broken bottles were observed in Magdaguhong cave.

Campbell [23] reported that human disturbances affect the habitat of all species present inside the cave due to soil compaction, changes in humidity, temperature, and may cause the cave fauna to abandon the caves due to trash toxic accumulation. Crickets are difficult to find, but in other caves hundreds of individuals can be seen in a relatively small area [5]. They are often important keystone species [5] in cave communities because they transport energy from the surface [5]. However, the public knows very little about the role of crickets in the ecosystem.

CONCLUSION

Among the cave crickets, *Macropathus* and *Ceuthophilus* were the most abundant and widely distributed. These species were observed in almost all types of microhabitats but more abundant on the walls and ceilings of deep zone areas. Walls in twilight zones were the most preferred microhabitats in terms of the number of crickets observed and genera present. Guano deposits appear to influence cricket abundance .Results showed that microhabitats play a role in the abundance and species/genera composition of crickets. Common threats to caves and the cave fauna include treasure hunting activities, vandalism, cutting of stalagmites and stalactites, and use of the cave as recreational area.

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