J. Judson Wynne and William Pleytez – Sensitive ecological areas and species inventory of Actun Chapat Cave, Vaca Plateau, Belize. *Journal of Cave and Karst Studies*, v. 67, no. 3, p. 148–157.

SENSITIVE ECOLOGICAL AREAS AND SPECIES INVENTORY OF ACTUN CHAPAT CAVE, VACA PLATEAU, BELIZE

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Cave ecosystems are considered one of the most poorly studied and fragile systems on Earth. Belize caves are no exception. This paper represents the first effort to synthesize information on both invertebrate and vertebrate observations from a Belize cave. Based on limited field research and a review of literature, we identified two ecologically sensitive areas, and developed a species inventory list containing 41 vertebrate and invertebrate morphospecies in Actun Chapat, Vaca Plateau, west-central Belize. Actun Chapat contains two ecologically sensitive areas: (1) a large multiple species bat roost, and (2) a subterranean pool containing troglobites and stygobites. The inventory list is a product of sporadic research conducted between 1973 and 2001. Ecological research in this cave system remains incomplete. An intensive systematic ecological survey of Actun Chapat with data collection over multiple seasons using a suite of survey techniques will provide a more complete inventory list. To minimize human disturbance to the ecologically sensitive areas, associated with ecotourism, we recommend limited to no access in the areas identified as "sensitive."

Cave ecosystems are one of the most fragile ecosystems on Earth (Elliott, 2000; Hamilton-Smith and Eberhard, 2000; Krajick 2001). Sensitivity of bats and other cavernicoles (cave dwelling organisms) is due to their vulnerability to human disturbance. Roosting bats (Mohr, 1972; Hall 1994, Hamilton-Smith and Eberhard 2000), maternity/nursery colonies (McCracken, 1986, 1988, 1989; Cockrum and Petryszyn, 1991; Brown *et al.,* 1993a, 1993b; Elliott 2000), and bat hibernacula (McCracken, 1988; BCI, 1989, 1992; Humphrey, 1969; Stebbings, 1971; Carlson, 1991; Harnish, 1992; Elliott, 2000) are highly sensitive to human disturbance. Because many troglobitic species (obligate cavernicoles) are endemic to a single cave, have low population numbers (Krajick, 2001), and are K-selected species (Hüppop, 2004), most troglobite populations are considered imperiled (Krajick, 2001). Despite their sensitivity to disturbance, cave ecosystems are poorly understood. Only a small fraction of caves in any region of the world has been assessed at an ecological system level (Culver *et al.,* 2004). While cave roosting bat species are well documented globally, troglobite richness and diversity remains poorly described. Culver and Holsinger (1992) estimate global troglobite diversity at 50,000 to 100,000 species.

The biota of Belize caves is poorly known. There is no overall estimate of cave-obligate species in Belize, but in the adjacent and comparable Yucatan Peninsula, Reddell (1979) identified 565 cavernicoles, including 34 troglobitic species. Reddell and Veni (1996) compiled an invertebrate inventory list of Chiquibul Cave, but most other cave invertebrate reports from Belize are brief accounts of new species discoveries or opportunistic collections (refer to Gertsch, 1973; Muchmore, 1973; Williams, 1976a, b, c, 1987; Reddell and Veni, 1976; Reddell, 1981; Rodriguez and Hobbs, 1989). There are few reports on cave-roosting bats (e.g., B. Miller and C. Miller, unpublished data; Elliott, 2000), even though almost one-third of Belize bats roost in caves during some point during their life cycle (Reid, 1997; BBIS, 2001). Epigean species (those inhabiting cave entrance areas, including reptiles, amphibians, and mammals) have not been addressed in the literature.

Throughout Mesoamerica, caves played a central role in Maya mythology (Bassie-Sweet, 1991). Consequently, activities of the ancient Maya are evidenced in many Belize caves. Because "archaeo-ecotourism" is an important economic resource for the country (Fernandez, 1989) and Actun Chapat (Mayan for "centipede cave") contains modified flowstone and other evidence of Precolumbian Maya use, the cave was targeted for development as a "show cave." However, prior to development, the Belize Institute of Archaeology (IOA) wanted additional information on the cave's large bat roost, as well as other ecological aspects of the cave. Thus, this current research was conducted to provide the IOA with this ecological assessment. The goals of this study were to: (1) identify all ecologically sensitive areas; and, (2) develop a species inventory list of Actun Chapat.

Methods and materials

Study area

Actun Chapat is located on the northern extent of the Vaca Plateau, west-central Belize (Figure 1). Situated in the Maya Mountain foothills approximately 20 kilometers south of the

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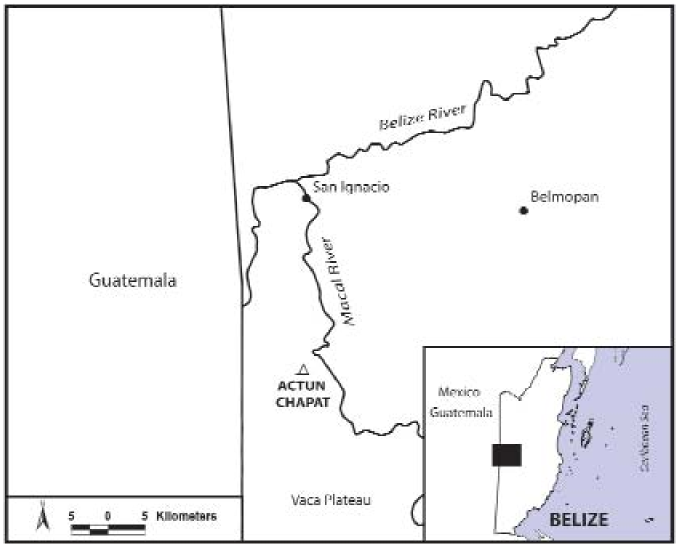

Figure 1. Location of Actun Chapat in west-central Belize situated along the northern extent of the Vaca Plateau.

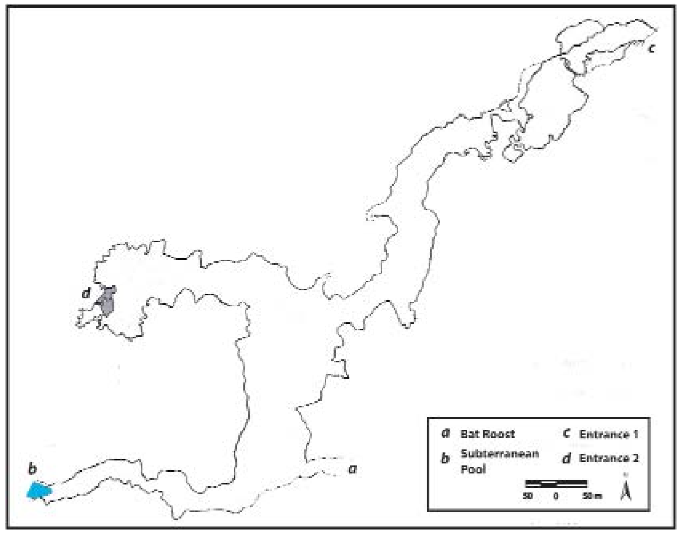

Figure 2. Map of Actun Chapat depicting (a) the multiple species maternity/nursery colony, (b) the subterranean pool, (c) entrance 1, and (d) entrance 2.

town of San Ignacio, this cave has two known entrances (Figure 2). "Entrance 1" is a horizontal entrance situated at the headwaters of an intermittent arroyo. "Entrance 2" is a vertical entrance approximately 10 m deep. Lands within ~1.6 km of Actun Chapat are used for cattle grazing and swidden agriculture. Archaeological research activities have been conducted within this cave since 1999 (C. Griffith, pers. comm.). Currently, this cave is infrequently used as a show cave.

Cave fauna terminology and taxonomy

We divided Actun Chapat cave biota into six cavernicole (cave dwelling organism) groups: troglobites, trogloxenes, troglophiles, stygobites, epigeans and guanophiles. The following definitions of each cavernicole group were derived from Culver and White (2005): (1) troglobites are characterized by no pigmentation, reduced eye development, elongated appendages, and require cave ecosystems for their entire life cycle; (2) trogloxenes spend a portion of their life cycle (e.g., hibernation, roosting, reproduction) in subterranean environments; (3) troglophiles are not obligate cave dwellers and may complete their life cycle either in subterranean or hypogean systems; (4) stygobites are aquatic species that spend their entire life cycle in underground waters; (5) epigean species are surface-dwelling organisms, but may occur as accidentals in caves (usually within cave entrances); and, (6) guanophiles are organisms that feed and/or reproduce in guano deposits, and may occur as both troglobites and troglophiles. Current taxonomy was verified for all vertebrates and most invertebrates using the Integrated Taxonomic Information System (ITIS; http://www.itis.usda.gov). Because taxonomy for most troglobites and stygobites is not yet available within the ITIS database, we used the taxonomy as classified by Reddell (1981).

Literature review

We reviewed published and unpublished literature to summarize prior biological research at *Actun Chapat*. To obtain additional information not available from the literature review, we also contacted researchers who have conducted field investigations in Belize.

2001 Baseline inventory methods

Bat survey

We surveyed for bats both inside and outside the cave. For four days, between 0900 hr and 1500 hr, we captured bats inside the cave with handheld nets (*sensu* Arita, 1996). To minimize disturbance to bats, Wratten #27 red camera filters were placed over the headlamp lights (Kunz, 1982). Dead bats found within the cave were also identified. Bats near Entrance 2 were captured using mist nets (Kunz, 1982) for one night from 1900 to 2330 hr. A net was placed below the vertical entrance, which was the closest entrance to the Zotz Na (Mayan for "bat house"), and the primary entrance used by the colony. Because exiting bats may abandon their roosts after capture (Kunz, 1982), we placed mist nets ~20 meters downslope from the cave entrance. While nets were open, three technicians constantly monitored the nets. Captured bat species were identified using a key developed by B. Miller (Wildlife Conservation Society, Belize), sexed, aged, weighed, evaluated for reproductive condition and photographed (*sensu* Kunz, 1982).

Invertebrate survey

Invertebrates were surveyed within three primary cave zones: (1) light zone, (2) twilight zone, and (3) dark zone. We established three parallel transects within the cave; one along each wall and one at the estimated centerline of the cave. To minimize impacts to invertebrate populations, species were identified in the field when possible. We recorded descriptive information on habitat and behavior for each species encountered. When invertebrates were collected for identification, one to five individuals per species were collected. Due to difficulties with export permits, invertebrates were identified, to the highest taxonomic level possible, using photographs and field information collected on morphology, biomechanics and habitat requirements. Information collected in the field was cross-referenced with existing literature, voucher photos, and consultations with taxonomic experts.

EPIGEAN VERTEBRATE SURVEY

We searched for epigean species using intuitive visual searches (Crump and Scott, 1994). In the light and twilight zones of both entrances, we searched for amphibians, reptiles, mammals, and animal sign in areas containing breakdown, within rock crevices and underneath rocks. All species encountered were visually identified or captured, identified and released. Species were identified using a combination of available literature and local indigenous knowledge.

SENSITIVE ECOLOGICAL AREAS

The majority of the cave was evaluated for ecologically sensitive areas. We considered an area ecologically sensitive if it contained sensitive, endangered or endemic species whose persistence is likely to be threatened by human disturbance. Due to the economic potential of the cave as a show cave, we identified specific zones within the cave as sensitive rather than providing an evaluation for the entire cave. These areas are considered microhabitats specific to sensitive and/or potentially endemic species.

RESULTS AND DISCUSSION

We identified 41 morphospecies in Actun Chapat (Table 1). These included four troglobites, 13 trogloxenes (bats), 13 troglophiles, three stygobites and nine epigean morphotypes (Table 2; Appendix 1). Of these taxa, three were tentatively considered guanophiles.

We identified two sensitive ecological areas: (1) a multi-species bat maternity/nursery roost and (2) a subterranean pool containing stygobites and a semi-aquatic troglobitic crab (Figure 2). The maternity/nursery roost is located below Entrance 2, within a side passage of Actun Chapat and is defined by three chambers, hereafter referred to as Zotz Na. Chamber 1 contained approximately 15 roosting bats and contains at least three *Phyllostomid* spp. The second chamber also contained roosting bats. However, it was difficult to determine if bats were roosting in this chamber or if they moved from Chamber 3 into Chamber 2 due to our presence. A large maternity/nursery colony is located in Chamber 3. This roost contained two primary species: *Natalus stramineus* and *Mormoops megalophylla*. In July 2001, we observed an estimated 7 x 3 m of cluster of hairless pups. This nursery colony was located at the approximate center of Chamber 3. Additionally, we identified two important sources of nutrient input into the cave: (1) the multi-species bat roost, and (2) the sinkhole entrance, known as Entrance 2.

Table 1. Results of the 2001 survey and literature review provided as a summary by cavernicole group.

Cavernicole Group	2001 Survey	Literature Review	Total
Troglobite	3	1[a]	4
Trogloxene (bats)	8	5[b]	13
Troglophile	12	1c	13
Stygobite	2	1	3
Epigean	9	-	9
Total	34	5	41

[a]Troglobite identified by Reddell and Veni (1996).

[b]Bat species were inventoried during field research conducted by B. Miller and C. Miller (pers. comm., 2004).

[c]Photograph of epigean species was taken by D. Billings during a 2005 cave survey expedition.

The dearth of information on Belize cave biodiversity underscores the need for a national effort to systematically inventory cave biodiversity. Presented here is the first species inventory of a Belizean cave. We identified 41 morphospecies from a variety of systematic groups, including both vertebrate and invertebrate species. Nineteen of these morphospecies were cave-dependent. Also, our findings identified a multi-species bat maternity/nursery roost, and a subterranean pool containing stygobites and a troglobitic crab. Both of these areas should be considered sensitive ecological resources.

Roosting bats are highly sensitive to human disturbance (Mohr, 1972; Hall, 1994; Hamilton-Smith and Eberhard, 2000). To evaluate the importance of the bat roost, we applied the conservation criteria derived from studies conducted by Arita (1993, 1996). Arita suggests that high bat species diversity and the presence of listed (threatened or endangered) or rare species can be used to identify the conservation priority of cave bat roosts. From a study of 36 caves in Yucatan, México, Arita (1996) identified 22 caves (61%) with one to two species, eight (22%) with three to five species and six (17%) with seven to nine species. In México, Arita (1993) suggests that roosts containing multiple species (> 6 species) should receive special management consideration due to their "unusually high species richness." Using this information, we developed a rank system, which identifies < 2 species as low diversity, 3 to 5 species as medium and > 6 species as high diversity. Actun Chapat contains between 10 and 13 roosting bat species (13 if considering the three unidentified individuals to represent distinct species). Therefore, this cave satisfies our high diversity criterion. There were no listed or rare species identified within Actun Chapat. However, the *M. megalophylla* colony is in decline, and is sensitive to disturbance. Although we did not attempt to count this colony, it is considered the largest colony in Belize (B. Miller, pers. comm. 2003). Because Mormoopid bats rarely form large colonies (> 100,000 individuals; Arita 1996) in Yucatan, this colony may

Table 2. Inventory list by cavernicole group of species identified at Actun Chapat. For undescribed invertebrate species, closest taxonomic identification is provided (taxonomic level and common name are provided in parentheses).

Morphotype	2001 Survey	B. Miller and C. Miller (unpublished data)	Reddell and Veni (1996)	Elliott (2000; pers. com., 2005)	Billings (2005)
TROGLOBITE					
Paraphrynus sp./*Paraphrynus raptator*? (whip scorpion)	*		*		
Lithobius sp. (millipede)	*				
Coleopterea (Order; beetle)[a]	*				
Prostigmata (Suborder; mite)	*				
TROGLOXENE					
Peropteryx macrotis	*				
Mormoops megalophylla	*	*		*	
Pteronotus parnellii		*			
Pteronotus personatus		*			
Pteronotus davyi		*			
Phyllostomid sp.	*				
Trachops cirrhosus	*				
Glossophaga sp.				*	
Glossophaga soricina	*	*			
Artibeus jamaicensis	*			*	
Natalus stramineus	*	*			
Myotis sp.	*				
Myotis elegans		*			
TROGLOPHILES					
Gastropoda (Class; snail)	*				
Arachnida (Class; spider)	*				
Loxosceles sp. (recluse spider)	*		*		
Diplopoda (Class; millipede)	*				
Littorophiloscia sp. (pillbug)	*				
Mayagryllus apterus?	*				
Coleoptera (Order; 3 beetle spp.)[a]	*				
Tenebrionid beetle (Zophobas sp.)					*
Tineidae (Family; micro-lepidopteran moth)	*				
Prostigmata (Suborder; 2 mite spp.)	*				
STYGOBITE					
Macrobrachium catonium?	*		*		
Typhlopseudothelphusa acanthochela			*		
Rhamdia guatamalensis?	*		*	*	
EPIGEAN					
Order Araneae (spider sp.)	*				
Citharacanthus meermani	*				
Centruroides gracilis	*				
Blaberus giganteus	*				
Blaberus discoidales	*				
Sphaeroceridae (Family; dung fly)	*				
Eleutherodactylus alfredi	*				
Lepidophyma flavimaculatum	*				
Lepidophyma mayae	*				

[a]Species tentatively considered guanophiles. For a complete inventory list by taxonomic order, refer to Appendix 1.

be unique to the Yucatan Peninsula. Thus, this cave meets one, and potentially both, of these criteria.

Additionally, roosting bats are vitally important to cave ecosystems because they transport organic matter from the outside environment into a cave via guano. The presence of bats and their guano in caves are considered vital to cave productivity (Arita, 1996; Krajick, 2001) and may result in high cavernicole species diversity, large biomass of organisms (Harris, 1970), and endemism (Arita, 1996). Subsequently, if bats abandon a cave, nutrient transport will be suspended, and the persistence of cave fauna may be in jeopardy (Nicholas, 1956). None of the cavernicole species identified within Actun Chapat are considered imperiled, but many invertebrate species identified are likely reliant upon the nutrient load provided by roosting bats. However, proper management of the bat colony will likely insure persistence of other cavernicoles.

Subterranean pools and small watercourses are highly sensitive due to the presence of distinctive and specialized stygobites (Hamilton-Smith and Eberhard, 2000). Stygobites, including salamanders, shrimp, crayfish, and crabs, are often long-lived, have small population sizes and reproduce slowly (Elliott, 2000; Krajick, 2001). Consequently, excessive disturbance to the stygobites in Actun Chapat may severely disrupt population dynamics, so that the population trends towards extirpation or perhaps extinction. However, we have no data to quantify sensitivity thresholds at either an individual stygobite or community level, nor have there been any efforts to develop conservation management criteria for stygobites in either southern México or northern Central America. Thus, we have no comparative framework for assessing the sensitivity of the two stygobite species and the semi-aquatic troglobitic crab, or evaluating the conservation priority of this community.

If protection of biodiversity is a management priority for this cave, the bat maternity/nursery roost and subterranean pool should remain undisturbed. Because declines in roost populations have been correlated to recreational caving activities as well as scientific investigations (Stebbings, 1971; Brown and Berry, 1991; Carlson, 1991; Cockrum and Petryszyn, 1991), the large multiple-species maternity/nursery roost warrants high consideration as a management priority. Activities perceived as minor, such as briefly entering a roost area, or shining a light within a roost, may result in decreased survivorship (McCracken, 1988) or permanent abandonment (McCracken, 1988; Cockrum and Petryszyn, 1991) of the roost. If this were to occur, the removal of the guano nutrient input into Actun Chapat would likely have a negative cascading effect on the entire cave ecosystem. Also, no taxonomic studies on the stygobites and troglobitic crabs have been conducted. Therefore, we do not know if these species are endemic to Actun Chapat. Similar species have been described from nearby caves, so the Actun Chapat stygobites and troglobitic crab may represent subpopulations. If this is the case, we do not know the connectedness of these subpopulations to other cave systems. If this pool is connected to other caves containing these species, immigration and emigration of individuals between caves will likely be possible. Thus, persistence may be driven by hydrologic connectedness to other populations in nearby caves. Repopulation by new individuals to Actun Chapat may then be possible. Conversely, if these species are endemic, or this community is isolated and the potential for repopulation is restricted, then this pool should receive special management consideration. Because the population dynamics of cave catfish, shrimp and crabs in Belize, and specifically Actun Chapat, are unknown, we do not know the impacts on these species of repeated or prolonged human disturbance. Until endemism and/or the connectedness of this pool to other caves are determined, and an understanding of population dynamics of these taxa obtained, we recommend the subterranean pool not be disturbed.

Although likely justified from a resource management perspective, we recognize identifying the entire cave as “no” or “restricted” access will be highly controversial for the owner and local community. Therefore, to provide some protection of the sensitive ecological areas and the cave ecosystem as a whole, we have identified an approach that may assist in the management of these resources. Using a modified ranking system developed by McCracken (1988, 1989), we divided the cave into green, yellow and red zones. Green zones are open to recreational and research activities. Yellow zones are quiet zones for recreational cavers, and research activities should occur only during certain times of the year. Red zones are off-limits to recreational cavers and used by researchers only in special cases.

We have delimited four suggested use zones within Actun Chapat; two green, one yellow, and one red (Figure 3). Green zone 1 extends from Entrance 1 to the entrance of the south-trending passage (the passage containing Zotz Na and subterranean pool). Green zone 2 extends from Entrance 2 to the entrance of this passage. Although we have observed troglobites and other cavernicoles throughout this passage, responsible recreational caving and research within these areas is considered a good compromise between affording some level of protection to sensitive cave resources while supporting regional economic activities. Separating the two green zones is a yellow zone. Because this zone is approximately 100 meters from the entrance to the Zotz Na passage, reducing visitant noise levels while traversing this area will reduce disturbance to bats. Establishment and use of a trail connecting Entrance 1 and Entrance 2 would further reduce impacts to cave biota. From the southern edge of the yellow zone southward is a red zone. This passage contains both sensitive ecological areas. The northern edge of the red zone is approximately 100 m from the passage containing the Zotz Na. Designating this zone as off-limits to recreational cavers is highly recommended. Research activities within this zone should occur only if determined necessary by IOA and Ministry of Natural Resources, Forest Department (MNRFD). To safeguard the persistence of this bat colony, research activities within both yellow and red zones should proceed when the bat roost is least susceptible to disturbance (*i.e.*, after reproductive cycle of a bat colony is complete), and under the direction of MNRFD.

A distinct contrast in nutrient loading exists between the horizontal entrance (Entrance 1) and the vertical entrance (Entrance 2). The configuration of the two entrances of Actun Chapat (one a vertical sinkhole entrance and the other a horizontal entrance), results in a chimney airflow effect (Tuttle and Stevenson, 1978; Pflitsch and Piasecki, 2003; Stuckless and Toomey, 2003). A chimney effect is characterized by seasonal oscillating airflow driven by changes in ambient temperature. During the winter, warmer internal air attempts to equilibrate

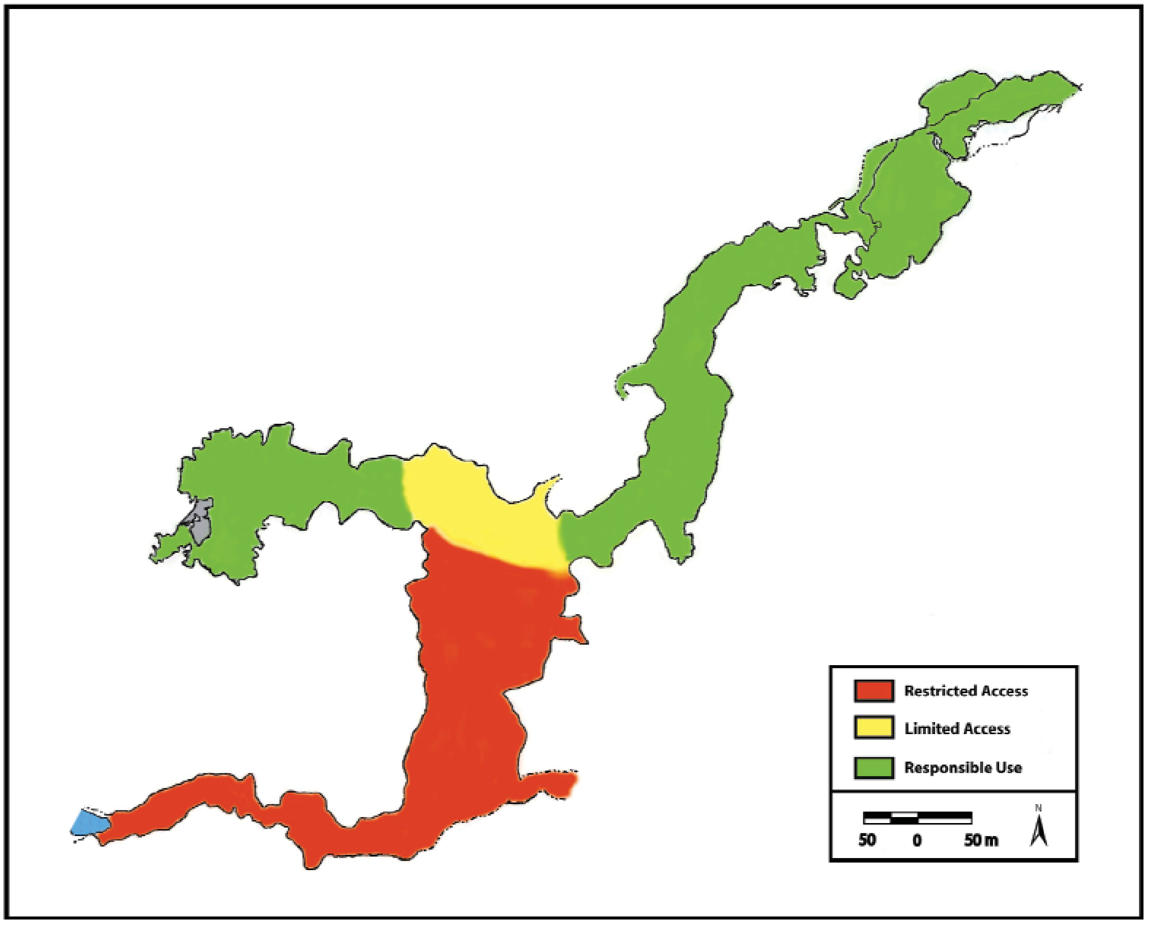

Figure 3. Recommended special use zones within Actun Chapat: Green (responsible use)–open year-round to responsible recreational caving and research activities, Yellow (limited access)–quiet zones for recreational cavers throughout the year with research activities permitted after bat breeding season, and Red (restricted access)–no access permitted to recreational cavers and access to researchers should be granted only in special cases.

with the cooler external air. As a result, warm air is expelled through the chimney entrance and ambient air is inhaled through the horizontal entrance. During the summer, a reverse chimney effect occurs as cooler internal air is expelled through the lower entrance as ambient air is inhaled through the chimney. The intensity of this effect is driven largely by cave structure.

At Actun Chapat, this cave breathing activity appears quite pronounced and may be more dramatic at the vertical entrance. This is tentatively supported by the disproportionate amount of nutrients found at the base of the vertical entrance compared to the horizontal entrance. The nutrient rich-Entrance 2 is likely driving species diversity and abundance. Entrance 1 is characterized by extensive breakdown and cobbles with virtually no organic material on the cave floor. Consequently, during our surveys of this entrance, we did not identify any fauna. Conversely, the cave floor below Entrance 2 contained a substantial amount of breakdown, leaf litter and other forest detritus.

During our research in July 2001, the inflow of air into the sinkhole entrance was so prominent, organisms passing over the entrance were sucked into the cave. This phenomenon gave rise to a myriad of insects flying continuously toward the surface, yet trapped within the air column between the entrance and the cave floor. Upon exhaustion, these insects would retire to the cave floor where we observed Alfred's rainfrog, two lizard species, and several Arachnid species preying upon them. The breakdown and forest detritus provides cover for both predator and prey species with the strong downdraft bringing detritus and organisms into the cave. Thus, cave structure, the breathing activity, and the influx of nutrients is supporting an ecosystem and potentially complex food web of epigean species. Although we do not consider Entrance 2 a sensitive ecological area, this entrance certainly warrants further study due to the unique predator-prey relationships borne-out by this chimney-effect breathing cave.

To date, this paper represents the first species inventory list of a Belize cave. In general, most biological information of Belize caves exists in the form of ad hoc invertebrate specimen collections and/or limited studies of cave roosting bats. None of this information has been synthesized to produce inventory lists on a per cave basis. Furthermore, we encountered no studies addressing wildlife using cave entrances. Although we now have a better understanding of Actun Chapat's biodiversity, ecological research in this cave system remains incomplete. To develop a more comprehensive inventory list, a survey effort consisting of extended duration sampling and sampling taxa using multiple techniques should be undertaken. Also, the epigean ecosystem at Entrance 2 offers a living laboratory for studying predator-prey interactions within a unique system.

These interactions and the cave-breathing phenomenon driving this system should be probed further.

Systematic research to inventory cave biota will not ensure the future of cave-obligate taxa. Currently, Belize has no legislation or programs to manage cave systems or safeguard the persistence of cavernicole populations. Delineating an entire cave system or cave passages within a system as red, yellow or green priority for conservation is only the first step. If land managers wish to manage these delicate ecosystems within a conservation paradigm, we propose the establishment of:

1. A ranking system to evaluate sensitivity for cave ecosystems and karst hydrologic systems;
2. A framework for identifying cave ecosystems for potential inclusion in the International Union for the Conservation of Nature (IUCN) World Heritage Site programme;
3. A listing of cave ecosystems and karst hydrologic systems targeted for restoration, and methods for cave restoration;
4. An education program to heighten awareness of Belizeans and tourists regarding the importance and fragility of cave ecosystems;
5. A training and certificate program for cave eco-tour companies and guides; and,
6. A review process of international and regional cave resource management documentation to obtain the information necessary for drafting cave management protection legislation.

Overall, the lack of information on Belize cave biodiversity and cave resource management programs underscores the need for a national effort to address these issues. Belize has a reputation for rich above ground biodiversity and innovative wildlife conservation practices. An effort to gain a greater understanding of Belize's subterranean fauna while concomitantly developing programs to manage cave ecosystems will bolster knowledge of its natural history, likely lead to new species discoveries, assist resource managers in identifying caves of high conservation priority and potentially provide managers with the infrastructure to manage these fragile systems.

Acknowledgements

We wish to thank the Belize Institute of Archaeology and Western Belize Regional Cave Project for their generous support throughout this project. We also thank the Chechem-Ha Lodge for providing field facilities and accommodations. J. Ascot, L. Berlin, B. Block, C. Chambers, C. Drost and K. Thomas donated field equipment. Valuable assistance and support in the field was given by J. Brown, C. Griffith, O. Raul Chi, S. Jacyna, and K. Whittenberg. Bats were handled by S. Jacyna and K. Whittenberg. C. Griffith and C. Helmke developed and provided the base map of Actun Chapat, courtesy of J. Awe and WBRCP. Thanks to D. Billings for providing images of Actun Chapat fauna from a 2005 cave mapping expedition. Also, thanks to C. Drost, J. Ove Rein, S. Peck, X. Prous and J. Reddell for insightful discussions on invertebrates. D. Ashley, C. Drost, B. Elliott, D. Fenn, D. Gillikin, M. Hansen, S. Jacyna, B. Miller, M. Santos, M. Sogge, and R. Toomey offered constructive comments on previous versions of this manuscript.

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Appendix 1 - Annotated List of Actun Chapat Cave Fauna

PHYLUM MOLLUSCA
Class Gastropoda (snails)
Order, genus and species undetermined. Troglophile? This snail was observed within a chamber, which contained a flowstone formation. This chamber was within the twilight zone below Entrance 2. This species may be cave adapted.

PHYLUM ARTHROPODA
Class Malacostraca
Order Isopoda
Family Armadillidiidae (terrestrial isopods)
Littorophiloscia sp. Epigean. This pillbug was frequently encountered within the breakdown beneath Entrance 2. This species is not cave adapted.

Order Decapoda
Family Palaemonidae (shrimp)
Macrobrachium catonium (Hobbs and Hobbs 1995)? Stygobite. This species was previously collected (Reddell and Veni 1996). We captured two individuals, which may represent the same species.

Family Pseudothelphusidae (crabs)
Typhlopseudothelphusa acanthochela (Hobbs 1986). Troglobite. Reddell and Veni (1996) identified this species within Actun Chapat.

Order Araneae
Family, genus and species undetermined. Epigean. This spider was documented below the sinkhole entrance. This spider was observed moving among the rocks and leaf-litter.

Family Theraphosidae (tarantula)
Citharacanthus meermani (Reichling & West 2000). Epigean. This species was observed within the twilight and transition zone of the cave. This species is not cave adapted.

Family Salticidae?
Genus and species undetermined. Troglophile. This spider was observed within the dark zone. It was observed perched on a rock. This spider was difficult to capture, and was capable of hopping and moving rather fast. This species was found deep within the dark zone and is presumed cave adapted.

Family Loxoscelidae
Loxosceles sp. Troglophile. This spider had a tan cephalothorax, gray abdomen, and red legs. It constructs condominium complexes of webs. It was observed directly below Entrance 1, the sinkhole. These haphazardly constructed webs formed mats on the ground. Thirteen webs were observed within a 1.5 by 5 meter area.

Order Amblypygida
Family Phrynidae
Paraphrynus sp. or *Paraphrynus raptator* (Pocock 1902). Trogloxene. The giant tailless whip scorpion was observed within the dark zone of the cave. This species is not cave adapted.

Order Trombidiformes
Family, genus and species undetermined. Two troglophillic mites. One species was found within the leaf litter below the sinkhole entrance (Entrance 2). The second species was a red-bodied mite, observed within the Zotz Na and within a narrow passageway. The ground of both locations was guano covered. Neither species is cave adapted.
Family, genus and species undetermined. One troglobite. One species was observed within the dark zone and had no pigmentation. This species is cave adapted.

Order Scorpiones
Family Scorpionidae
Centruroides gracilis (Latreille 1804). Epigean. This species was observed within the twilight and transition zone of the cave. This species is not cave adapted.

CLASS Chilopoda (centipedes)
Order Lithobiomorpha
Family Lithobiidae
Lithobius sp. Troglobite. This cave adapted Lithobiid centipede was found within the dark zone of the cave. It was observed within bat guano. This species is tentatively considered a guanophile.

CLASS Diplopoda (millipeds)
Order, family, genus and species undetermined. Troglophile. This species was observed throughout the all light-zones of the cave. This species occurs in high densities throughout all light zones, and is presumably the namesake for the cave. Its body is black and orange striped with red legs and feet. When disturbed, this species coils into a disk. This species is not cave-adapted.

CLASS Insecta
Order Blattaria
Family Blaberidae (giant cockroaches)
Blaberus giganteus (Linnaeus 1758). Epigean. This species was observed within the light zone of Entrance 2. This species was not cave adapted.
Blaberus discoidalis (Serville 1839). Epigean. This species was observed within the light zone of Entrance 2 beneath the leaf litter. Three individuals, 3–5 cm in length, were observed within the leaf litter. This species is not cave adapted.

Order Orthoptera
Family Phalangopsidae (cave crickets)
Mayagryllus apterus (Grandcolas and Hubbell 1994)? Troglophile. This species was observed within the twilight and dark zones of the cave. Elliott (pers. com. 2005) also observed this species during his 1992-93 research. During his research, he observed this species feeding on bat guano. This species is tentatively listed as a troglophile, but may be epigean.

Order Coleoptera
Family Tenebrionidae
Zophobas sp. Troglophile. This species frequently scavenges on guano and bat carcasses in tropical caves (S. Peck, pers. com. 2005). This species was photographed by D. Billings (2005) and tentatively identified by S. Peck (Carleton University, Ottawa, Canada). This species is not cave adapted.
Family, genus and species undetermined. Three troglophiles. Two beetle species were observed within the light zone beneath the leaf litter of Entrance 2. One species was observed within the dark zone of the main cave passage from Entrance 2. Neither species is cave adapted.
Family, genus and species undetermined. Troglobite. One species was observed burrowing into a circular pile of bat guano. This species is presumed to be a cave-adapted guanophile.

Order Lepidoptera
Family Tineidae
Genus and species undetermined. Troglophile? This species was observed within the Chamber 3, Zotz Na. It had a silken cocoon, which formed a protective shell, and it emerged partially from one end to feed. It formed a carpet layer over the guano. W. Pleytez aptly described the ground as "being completely alive" with this species. This species is tentatively considered a guanophile.

Order Diptera
Family Sphaeroceridae (dung fly)
Genus and species undetermined. Epigean. This species was observed within the dark zone. It was dark gray in color with red eyes. This species is not expected to be cave adapted.

PHYLUM CHORDATA
Class Actinopterygii
Order Siluriformes
Family Pimelodidae (catfish)
Rhamdia guatemalensis (Günther 1864)? Stygobite. This species was captured with a handheld net from the subterranean pool within the cave's dark zone. This species has no pigmentation and reduced eye development. Reddell and Veni (1996) and Elliott (pers. com. 2005) also identified this species. Elliott (pers. com. 2005) had this species

tentatively identified by researchers at the Texas Memorial Museum, Austin. This catfish is a cave-adapted species.

Class Mammalia
Order Chiroptera (Bats)
Family Emballonuridae
Peropteryx macrotis (Wagner 1843; Lesser Dog-like Bat). Trogloxene. This species was documented by B. Miller and C. Miller (unpublished data).

Family Mormoopidae
Mormoops megalophylla (Peters 1864; Ghost-faced bat). Trogloxene. We captured this species both within Zotz Na and in mist nets outside the cave. B. Miller and C. Miller (unpublished data) also documented this species.
Pteronotus parnellii (Gray 1843; Parnell's mustached bat). Trogloxene. We captured this species within Chamber 1, Zotz Na and in the mist nets below Entrance 2. B. Miller and C. Miller (unpublished data) also documented this species.
Pteronotus personatus (Wagner 1843; Wagner's mustached bat). Trogloxene. This species was documented by B. Miller and C. Miller (unpublished data).
Pteronotus davyi (Gray 1838; Davy's naked-backed bat). Trogloxene. This species was documented by B. Miller and C. Miller (unpublished data).

Family Phyllostomidae
Phyllostomid sp. Trogloxene. One unidentified Phyllostomid species was captured in the mist nets below Entrance 2.
Trachops cirrhosus (Spix 1823; fringe-lipped bat). Trogloxene. We captured this species within a cylindrical recess in the cave ceiling of Chamber 1, Zotz Na.
Glossophaga sp. Trogloxene. In 1992 and 1993, Elliott (2000) documented individuals to genus level within Actun Chapat.
Glossophaga soricina (Pallas 1766; Pallas's long-tongued bat). Trogloxene. We captured this species within Chamber 1 of the Zotz Na.
Artibeus jamaicensis (Leach 1821; Jamaican fruit-eating bat). Trogloxene. One individual was captured with a handheld net. It was roosting with two other individuals (possibly females) within a cylindrical recess in the cave ceiling of Chamber 1, Zotz Na. Once this species was captured the bats apparently abandoned this roost. In 1992 and 1993, Elliott (2000) also documented this species within the cave.

Family Natalidae
Natalus stramineus (Pallas 1766; Mexican funnel-eared bat). Trogloxene. We observed this bat within all chambers of the Zotz Na. However, it was only observed roosting within Chamber 3, where it is the dominant species of the large maternity roost. B. Miller and C. Miller (unpublished data) also documented this species.

Family Vespertilionidae
Myotis sp. Trogloxene? One unidentified Myotis species was captured in the mist nets below Entrance 2.
Myotis elegans (Hall 1962; elegant myotis). Trogloxene. This species was documented by B. Miller and C. Miller (unpublished data).

Class Amphibia
Order Anura
Family Leptodactylidae
Eleutherodactylus alfredi (Boulenger 1898; Alfredo's rainfrog). Epigean. We captured this frog within the breakdown beneath Entrance 2. This species is not cave adapted and is considered epigean.

Class Reptilia
Order Squamata
Family Xantusiidae
Lepidophyma flavimaculatum (Duméril 1851; yellow-spotted night lizard). Epigean. We observed this species in the breakdown beneath Entrance 2. We observed one lizard capture and consume a wasp. This species is not cave adapted.
Lepidophyma mayae (Maya night lizard). Epigean. We observed this lizard in the breakdown beneath Entrance 2. This species is not cave adapted.