Cueva del Diablo: a Bat cave in Tepoztlan

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Abstract

In Mexico, almost half of the 140 species of bats use caves as alternative or primary roosts. One volcanic cave that houses important colonies of these animals is *Cueva del Diablo* in Tepoztlan, Morelos, central Mexico. At least three bat species have been reported in this cave. One of them, the Mexican long-nosed bat (*Leptonycteris nivalis*), is of particular importance in economical and ecological terms. This species migrates from central to northern Mexico and southern United States in mid spring and come back in mid autumn. In Mexico, L. nivalis is classified as a threatened species, and in the U.S. as an endangered one.

Owing to the fact that Cueva del Diablo is the only known roost in which this species mates, the cave was proposed by us as a sanctuary to the CONANP (National Commission of Natural Protected Areas) in 2004. In addition to this proposal, the PCMM (Program for Conservation of Mexican Bats) has conducted environmental education efforts in the region as an attempt to modify the negative ideas about bats and to share the information concerning their importance and that of caves for them.

Other PCMM studies conducted in this cave focus on the diet of the species and understanding its mating system, among the first studies on those subjects for this species. This document represents a compilation of those works in Cueva del Diablo with emphasis in their importance for the general conservation of bats and caves.

Introduction

With 1116 extant species recognized worldwide, bats are second only to rodents in terms of total number of species (Simmons, 2005; Wilson and Reeder, 2005). Diversity of bats is noteworthy not only by quantity but also because their evolutionary radiation has led the group to an unparalleled ecological and morphological diversification. Bats occupy several trophic guilds, from primary consumers to predators; they roost in many types of natural and human-made structures in numbers from a few animals to millions, creating the greatest concentrations of warm-blooded vertebrates (Medellín, 2003).

There are 9 families of bats in Mexico that comprises 64 genera and 140 species, 15 of which are endemic (Tejedor, 2005; Ceballos *et. al*., 2002). The Mexican bat fauna is rich because of the country's complex topography, the fact that Mexico contains virtually every known vegetation type (Rzedowski, 1978), and because it has three distinct biogeographical elements: neotropical, neartic (the limits of which are entirely contained within Mexico's borders), and endemic (Medellín, 2003).

Chiropterans play several major ecological roles in many ecosystems. Insectivorous bat species are the primary consumers of nocturnal insects, and given the relatively large volumes consumed (up to 100% of body weight per night) and the long distances traveled (several km per night), these bats are thought to play a major role in regulating nocturnal insect population and intransporting nutrients across the landscape (Kunz and Pierson, 1994). Bats are major predators of nocturnal flying insects, and an important biological control agents of insect pests (Russell, *et. al*. 2005; Medellín, 2003), including cucumber beetles, June bugs, corn borers, Jerusalen crickets, leafhoppers and noctuid moths which are important agricultural pests on such crops as corn, spinach, pumpkins, cotton, potatoes or tomatoes (Whitaker, 1993).

Bats are pollinators and seed dispersers for a number of ecologically and economically important plants (Kunz and Pierson, 1994). They pollinate plants associated with tropical and subtropical dry areas, such as agaves, cactus and a variety of tropical trees (Arita and Wilson, 1987). They disperse seeds occurring in the plant families to which figs and relatives belong, like Moraceae and Piperaceae, among others (Fleming, 1987). Worldwide, there are more than 750 plant species that have been listed as visited by bats (von Helversen and Winter, 2003). Flower – visiting bats in Mexico are represented by 12 species, most of which have restricted distribution; two of them are endemic to the country, two others to Middle America and ten use caves as a main or alternative roost (Arita and Santos del Prado, 1999).

Despite the importance of bats for ecological processes and for humans, this group of animals is facing great population declines and extinction pressures worldwide (Hutson *et. al*., 2001). About 24% of bats (248 species) are considered at risk by the IUCN (2006): 32 critical endangered, 44 endangered and 172 vulnerable. Mexico has a similar percentage of species at risk but at a national level: 12 under special protection, 15 threatened and 4 endangered, including 5 endemic species (SEMARNAT, 2002).

Over the past 400 years, at least 9 species of bats have become extinct (IUCN, 2006). Bat populations in many countries are thought to have declined over the past 50 – 100 years, and although the evidence for such reductions is often circumstantial, there are cases where declines have been well documented (Mohr, 1972; Stebbings, 1988; Rabinowitz and Tuttle, 1980; R. A. Medellín, pers. obs.).

Factors behind the decline of bat populations are often related to human destruction of habitat and roosts

(Medellin and Gaona, 2000). An increasing human population brings with it extra demands for land, resources and food, which often results in the degradation, destruction or fragmentation of certain habitat types with a concomitant effect on bat populations (Hutson *et. al.*, 2001). Impacts of agriculture and its derivatives (e. g. reduction of fallow periods, overgrazing, loss of important plant species for bat foraging, replacement of natural vegetation with cash crops and monoculture as a result of that, use of pesticides that affects insect fauna and are potentially sub-lethal for bat's breeding performance, among others), as well as industrial activities, fire, deforestation, introduced predator species or pollution, can affect negatively bat populations (Hutson *et. al.*, 2001).

Linking bats to witchcraft and magic has given rise to many of the fears people have about them (McCracken, 1992). Within the same topic, the feeding habits of the vampire have been so exaggerated and confused with Old World legends that the animal is of particular interest. It has been considered a threat both to people and to their domestic animals in Latin America (Nowak, 1994), where, as an ironic fact, populations of vampire bats have increased sharply in areas to which European livestock have been introduced (Hutson *et. al.*, 2001). Common vampire bat is extensively persecuted as a vector of rabies, that is transmitted to cattle and other ungulates on which it feeds, although its incidence is low (<1%). The main method of control is the use of anticoagulants applied to individual bats captured by mist nets, which are dispersed to other individuals in the roost by allogrooming (Brass, 1994). However, roosts have also been burned, gassed and dynamited, with the loss of large populations of harmless or beneficial bats as well as other cave fauna (Hutson, *et. al.*, 2001).

The importance of bat caves

Indeed, roost site disturbance and destruction is another great threat for bats, and this can be represented by the loss or alteration of trees and buildings, guano mining, deliberate destruction, or not regulated tourism or caving (Hutson, *et. al.*, 2001).

Roosting ecology of bats can be viewed as a complex interaction of physiological, behavioral, and morphological adaptations and demographic response. These animals spend over half their lives subjected to the selective pressures of their roost environment. For many bats the availability and physical capacity of roosts can set limits on the number and dispersion of roosting bats, and this in turn can influence the type of social organization and foraging strategy employed (Kunz, 1982). Roosts are important sites for mating, hibernation, and rearing young. They often facilitate complex social interactions, offer protection from inclement weather, promote energy conservation, and minimize risks of predation (Villa-R, 1967; Kunz and Lumsden, 2003).

Underground sites, both natural (e. g. caves) and artificially created (e. g. mines), are crucial to the survival of many bat species worldwide (Hutson *et. al.*, 2001). In relation to other roosts, caves stand out because of their extended use among these organisms (Avila, 2000). A great proportion of world's bats can be considered cave – dwellers and, probably, caves host more individuals than other roosts, even combined (Hill and Smith, 1984). Besides that, great dimensions and complex topography in one cave only can offer several perch sites for different individuals or colonies (Medellín and López – Forment, 1985; Hill and Smith, 1984; Kunz, 1982) as well as different microclimates (Medellín and López – Forment, 1985).

In Mexico, there are over 10 000 caves (Lazcano, 2001), mostly karstic but also in sandstone, and a few caves inhabited by bats are volcanic in origin. Almost half of the country's bat species use caves as primarily or alternative roosts (Arita, 1993). However, a survey made by Ruiz (2006) yielded a total of only 442 Mexican caves with information on bats.

Cueva del Diablo

One of the relatively well known bat caves in Mexico is Cueva del Diablo, located in Tepoztlán, Morelos. This municipality belongs to the Transvolcanic belt physiographic province, in the Anahuac Lakes and Volcanoes subprovince, where Volcanic Sierra of Ajusco, the Chichinautzin volcano and Tepozteco Sierra stand out (Caballero, 2004).

Flora in Tepozteco Sierra encircles the transition zone between the subtropical evergreen, the template (oak and pine) and the tropical deciduous formations (Hoffman *et. al.*, 1986). The cave is located in the latter type of vegetation, characterized by a semi-warm wet climate with summer rain (A) C (w_2) (w) i g (García, 1986) and in an altitude of 1850 masl. In summer, it presents an average external temperature of 28°C during day, which decreases while entering the cave down to 16°C in the majority of internal chambers.

A full description of the cave was made by Hoffman *et.al.* (1986). This refuge has a volcanic origin, from a subterranean lava flow that stopped, and eventually forms a various chamber's system with a 1 937m length (including all the ramifications) and a maximum depth of 110m respect the entrance (Hoffman *et. al.*, 1986).

Tepoztlan represents a transition point between neartic and neotropical faunas, and a confluence center of migratory species. In Cueva del Diablo there are three main bat species according their presence in the cave: *Leptonycteris nivalis*, *Pteronotus parnellii mexicanus* and *Desmodus rotundus* (Hoffman, 1986) and isolated captures of *Anoura geoffroyi* (Edmundo Huerta, pers. comm.), *Artibeus jamaicensis* (Rodrigo Medellín, pers. comm; Gabriela López, pers. comm.) and *Myotis velifer* (Rodrigo Medellín, pers. comm; Gabriela López, pers. comm.)

The naked – backed bat, moustached bat or leaf – lipped bat (Nowak, 1994) *Pteronotus parnelli* (Gray, 1843) is basically an insectivorous one (Fleming, 1972; Novick and Valsnys, 1964) and there are reports where a single colony of 600 000 individuals can consume between 1900 and 3000 kg of insects per night (Ortega, 2005). It normally perches in caves, preferring internal chambers with high humidity and temperature (Alvarez, 1963). In Cueva del Diablo, this bat locates in tunnel 20, sharing space with *Leptonycteris nivalis* (Caballero, 2004; Hoffman *et. al.*, 1986). *P. parnellii* distribution in Mexico goes through the neotropical zone from Sonora and Tamaulipas to Yucatán and Chiapas (Ortega, 2005), but it reaches north Argentina and Paraguay (Jiménez Guzmán y Zúñiga, 1992; Ramírez – Pulido *et. al.*, 1983). Although its conservation status is unknown, this bat is one of the most abundant and it can survive even in disturbed zones, so it's not considered

at risk (Ortega, 2005).

The common vampire bat, *Desmodus rotundus* (E. Geoffoy, 1810) characterizes for its feeding habit, which consists basically in blood from different mammals (primarily cattle). They can drink 20ml of blood per individual per day and take 40 minutes feeding (Greenhall, 1972). Colonies are commonly comprised by 20 – 100 individuals, but there are reports of groups from 500 to 5000 bats (Crespo *et. al*., 1961). *D. rotundus* can live in caves, crevices, dark constructions and trees (Suzán, 2005). These bats can transmit the paralytic rabies virus, which causes economical loss in Latin America (Hoare, 1972). Also from the neotropical region, this bat's distribution goes from north Sonora and Tamaulipas in Mexico to Argentina (Villa - R, 1967).

Leptonycteris nivalis (Saussure, 1860), the Mexican long – nosed bat, is the largest Mexican glossophagine bat species. As other nectarivorous bats, it has short ears and leaf nose, and the face and tongue are elongated (Arita, 2005). It occupies a great variety of habitats, from template to tropical and desert zones, principally in transition areas between coniferous and tropical deciduous forests ones. Its distribution is restricted to North America, from south Texas and New Mexico, where it establishes from June to August, to central Mexico where it remains during winter (Arita, 1991; U. S. Fish and Wildlife Service, 1994). It seems fluctuations in numbers of this bat respond to food availability (Fleming and Nassar, 2002; Schmidly, 1991; Easterla, 1972) and the migratory movements follows the "nectar corridors" formed by the flowering plants that comprises their diet (Fleming et. al., 1993). But despite some anecdotal information about this subject, no detailed study has been conducted on the specific factors that may influence bat abundance, reproduction and growth, especially as these factors are related to food availability and roost site conditions (Arita and Martínez del Río, 1990). This basic information is essential for the conservation and management of *L. nivalis* (U. S. Fish and Wildlife Service, 1994).

At the same time, there is little information about its diet and reproductive pattern. A few studies found that they fed on nectar from flowers of *Agave* and some convolvulaceous, bombacaceous and cactacean, as well as other agavaceous plants (Sánchez, 2004; Téllez, 2001; Butanda-Cervera *et. al*., 1978; Alvarez and González, 1970; Villa-R, 1967).

It appears that mating occurs in southern Mexico during winter and females occupy northern caves (Texas and New Mexico, and northern states of Mexico) to form maternity colonies in late spring and summer (Tellez, 2001; Davis, 1974; Easterla, 1972). The migratory behavior of *Leptonycteris nivalis* is reflected in its seasonal presence both in the United States and in northern and southern Mexico (Tellez, 2001; Cockrum and Petryszyn, 1991; Moreno – Valdez, 1998; Easterla, 1972).

Caves are the main roosts of four of the nectar – feeding Mexican bats and another six species use caves as alternative roosts (Arita and Santos del Prado, 1999). The former is the case of *L. nivalis*, a colony species that roosts in caves, mines, tunnels and occasionally in unused buildings, hollow trees and sewers (Pfrimmer and Wilkins, 1988). Some cave populations, like those in Cueva del Diablo, can be composed by thousands of individuals (Hoffman et. al., 1986; Easterla, 1972).

Research

Research works concerning bats in Cueva del Diablo had been made primarily by the Laboratory of Vertebrate Ecology, Institute of Ecology, UNAM. These investigations are important contributions to the knowledge about the priority species *Leptonycteris nivalis* and that of this cave for it.

Manual de bioespeleología (Biospeleology manual), Anita Hoffman, José Palacios Vargas and Juan B. Morales-Malacara (1986)

Alter 6 years imparting 11 Field Biology courses focused on biospeleology at the UNAM, Hoffman *et. al*. decided to publish this work in 1986. It was made as a guideline in Spanish for biospeleologists, to encourage for more studies and to share results of those years of research.

The publication includes a recompilation of historic data about general aspects of caves, and more specifically, about biospeleological studies made in Mexico. Also, it presents a brief relation concerning cave animals and ecological features of that fauna and its environment. This manual describes materials and methods to carry out researches of this matter and exposes the results of the eleven expeditions made in several caves of Morelos and Guerrero states.

They visited 8 caves in two states from September 1977 to March 1983. They described the caves including flora and fauna and elaborate the maps for five of them in Morelos and three in Guerrero. Also, they took samples, according the *biotopos* for: bat fauna and its symbionts, water fauna, guano fauna, little about interstitial fauna, and floor and wall fauna. A total of 75 families, 135 genera and 206 species new reports for the country are presented in this work and 10% of the latter are first – known cave species for Mexico and for the science.

Concerning Cueva del Diablo, two excursions allowed to compile information about location, climate, vegetation, geology and a full internal description of the cave, including a complete map. With regard to flora and fauna, they reported: 8 species and genera and 6 families of eumycota (true fungi); 9 species and genera and 11 families of arachnids; 8 species, 10 genera and 10 families of mites; 1 genera and 2 families of centipedes; 1 family of millipedes; 10 species, 25 genera and 23 families of insects; and 3 species, 3 genera and 2 families of bats.

In relation to cavities *biocenosis*, bat populations constitute an important factor in the establishment and development of many other populations of cave organisms, because their feeding habits contribute, through guano, with a great variety of nutrients. Also in its bodies, bats house lots of parasites and guests.

*Migración de los murciélagos – hocicudos (*Leptonycteris*) en el trópico mexicano* (Migration of long - nosed bats (*Leptonycteris*) in tropical Mexico), Juan Guillermo Téllez Zenteno (2001)

This work proposes the existence of a segregation feeding mechanism that allows niche segregation between *Leptonycteris curasoae* and *L. nivalis* and it try to prove the hypothesis of altitudinal movements of these bats. Reproductive patterns, population fluctuations and feeding habits of the species were studied

using stable carbon isotopes in 11 caves located in tropical Mexico.

Genus *Leptonycteris* selects migratory behavior in the tropics based on the seasonal availability of food also making markedly seasonal its presence in the region around autumn and winter.

The lesser – long nosed bat presents only one reproductive pulse in the tropic, when females form great maternity colonies in the tropical deciduous forest.

The first report of a known mating refuge for the Mexican long – nosed bat in Cueva del Diablo its made in this research. The results indicate that there's only one reproductive pulse for this species, represented by the testicular activity of males and the copulations which occur mainly in November and December. It is probable that pregnant females of *Leptonycteris nivalis* are the ones that establish maternity refuges north during spring – summer. It seems also that unlike *L. curasoae*, it only appears to be one population through out the whole range of distribution for the Mexican long – nosed bat.

L. nivalis resulted much more specialized in CAM resources than *L. curasoae*, because it presents a limited use on C_3 metabolic derivatives. Out of this, it could by say that there is an ecological mechanism of feeding segregation between *Leptonycteris* species when both occupy tropical deciduous forest in Cuenca del Balsas. This in turn can be the reason for the overlapped distributions of these species in Mexican tropic.

Some results of this investigation had been useful to propose Cueva del Diablo to become sanctuary and to better understand the migratory, feeding and reproductive behavior of two ecological and economical important Mexican bat species.

Observaciones sobre la conducta reproductiva de Leptonycteris nivalis *(Chiroptera: Phyllostomidae) en Tepoztlán, Morelos, México* (Observations on reproductive behavior of *Leptonycteris nivalis* (Chiroptera: Phyllostomidae) in Tepoztlan, Morelos, Mexico), Luis Antonio Caballero Martínez (2004)

Based on observations and recordings with infrared cameras, this study is an attempt to describe the social structure and mating behavior, period and system of *Leptonycteris nivalis* during its stay in Cueva del Diablo. This species occupy the cave from September to February where a great fluctuation in group composition make difficult to establish a well defined social structure. According to the results, preliminarily it can be proposed that the Mexican long – nosed bat had established in Cueva del Diablo a promiscuous mating system conformed by multi-male and multi-female groups, with no evidence of harem or lek formation, territory defense, courtship or marked sexual dimorphism and where apparently mating is not random.

Mating period matches the resource availability peak in the zone and it's restricted to the last two weeks of November and first two of December with approximately one month duration, when male's testicular measures and weight are maximums. The latter together with a promiscuous mating can indicate presence of spermatic competition.

It is probable births occur in May during migration, and that maternity colonies could establish in northern Mexico and southern U.S. This way, gestation period lasts 6 months, which is considered to long for bats, so probably a fertilization or embryonic development delay take place in *L. nivalis*. Possibilities of polyestrous reproductive pattern in this species are almost none, so it probably presents a monoestrous one.

It is necessary to make more observations on the conduct of this bat all along its migratory trajectory, as well as genetic studies to confirm the data obtained during this study, but still it presents important information concerning reproductive ecology about the Mexican long – nosed bat that corroborate the importance of Cueva del Diablo for the species and contributes to the knowledge about it. This in turn can be another argument to apply strict protective measures that can guarantee a reduction in the number of persons that enter the cave, at least during the mating season of the species.

Dieta del murciélago magueyero mayor Leptonycteris nivalis *(Chiroptera: Phyllosomidae) en la Cueva del Diablo, Tepoztlán, Morelos* (Diet of the Mexican long–nosed bat *Leptonycteris nivalis* (Chiroptera: Phyllostomidae) in Cueva del Diablo, Tepoztlan, Morelos), Leslie Ragde A. Sánchez Talavera (2004)

This study documents plant species that conformed the diet of the Mexican long – nosed bat during its stay in Cueva del Diablo, although samples collection was made also in two mines north of the country in the same period. A great part of this bat's diet in the cave comprises no – CAM metabolism plants. Results identified 7 plant genera in 5 families: Cactaceae, Bombacaceae, Convolvulaceae, Fabaceae and Agavaceae, being the most represented species *Ipomoea arborescens* in first place and *Agave* sp. as second. Two new species of agaves were determined as part of the *Leptonycteris nivalis* diet and no differences between sex's and monthly diets were observed.

One of the steps the "Mexican long – nosed bat *Leptonycteris nivalis* recovery plan" (U.S. Fish and Wildlife Service, 1994) proposed, and the former research covers in some extent, is the necessity of an inventory about plant species this bat consume as food, according to sex, age, period and locality. Based on the knowledge of the foraging habitat this species use, they can be settled more and better decisions about protection and conservation of *Leptonycteris nivalis*.

Conservation and environmental education

According to Arita (1993), an effective plan for the conservation of Mexican cave bats would require a double strategy: the protection of caves with unusually high diversity and multispecies populations, and the management of cave bats of special concern (fragile, vulnerable and endemic species).

Certain analysis suggest that the Mexican long – nosed bat has declined in numbers over the past 30 years (Jones, 1976; Wilson *et. al.*, 1985), probably due to some of the human activities mentioned before. Currently this species is listed as Endangered by the IUCN (2006), and as Threatened by the NOM-059 in Mexico (SEMARNAT, 2002) since 1991.

In 1994 was approved the "Mexican long – nosed bat *Leptonycteris nivalis* recovery plan" between Mexico and the United States, where the steps to change risk status of the species to a lower category are outlined (U. S. Fish and Wildlife Service, 1994).

Additionally, the PCMM (Conservation Program for Mexican Bats) begins

its work to recover and to conserve the habitat and populations of bats that inhabit the country. To protect these animals, the program has a strategy based on three main axes: research (surveys, population size estimates, migration, ecology, reproduction, diet, genetics, and economic value, among others), environmental education (school programs, radio shows, traveling exhibits, community work, arts and crafts) and conservation actions (stewardship and protection by local communities, management plans, legal protection). The program carried out an initial prioritization process to identify the most important caves. Those priority caves contained large colonies of migratory bats and also faced imminent or ongoing damage by neighboring human population (Medellín, 2003). However, the PCMM has evolved so that is no longer limited to migratory bats, but include endemic species and those facing conservation threats that have been added in the Mexican list of species at risk (SEMARNAT, 2002).

The PCMM is now firmly assembled as a binational, multiinstitutional partnership based at Institute of Ecology, UNAM, with the participation of many other organizations. Currently, the program has presence in 18 states of México, where 26 caves are being monitored and 2 – 4 caves are added annually. The program has also initiated a vampire control operations in potentially problem areas, where it works with locals, researchers and public servers of environmental, cattle rising and health sectors. Priority caves where the program is working, have maintained the bat populations stable or they have increased (Medellín, 2003).

Cueva del Diablo was first monitored in 1996, when PCMM estimated 5 000 Mexican long – nosed bats; in winter 2001 – 2002 the numbers increased to 8000 – 10 000 (Medellín, 2003). Despite the importance of these bats, and of the cave for them, there's no legal protection actually for the cave and for the bat populations in it.

However, the PCMM also has achieved conservation success in the legislative arena. As a result of the promotion of the program in different venues, PCMM was called by the federal government to contribute to the recently passed Law of the Ecological Balance and Protection of the Environment. The PCMM suggested that all caves, natural crevices, and sinkholes be protected by law, because their importance for bats and for the recharge of aquifer. At the same time, the program's personnel contributed to the creation of a new category of federally protected areas, namely sanctuaries. A Sanctuary is a small area where it is necessary to protect an important population of particular species or an important segment of biological diversity, and where all resource extraction is banned. Caves are obvious, natural, and immediate candidates for this category (Medellín, 2003).

Following this idea, a group of researchers and students, coordinated by Dr. Rodrigo A. Medellín (chief researcher in the Institute of Ecology, UNAM and director of the PCMM) elaborated a study that proposes 10 priority caves with ecological and economical importance for become sanctuaries (in process), which was presented to the CONANP (National Commission for Natural Protected Areas) in 2004. Inside this proposal is Cueva del Diablo, because of its great colony of the threatened migratory nectarivorous bat *Leptonycteris nivalis*, its importance as a mating roost for this species (Tellez, 2001) and because vandalism and visiting are very common in the cave.

Concerning Cueva del Diablo, the PCMM had agreed with the local, state and federal authorities to work in the cave and with communities surrounding it since 2000. They'd developed a series of manual and educative activities for children and adults to show the benefits of bats and for the people to lose their fear about these animals. The program divided bats in six groups according to their feeding behavior (insectivorous, frugivorous, carnivores, ichthyophagous, hematophagous and nectarivorous) and created educational material that includes a natural story about each one and activity books for teachers and children. In the case of Cueva del Diablo, *Flores para Lucía la murciélaga* (Flowers for Lucía the bat) is the material which had been being used in four schools of four communities in Tepoztlan. At the same time, there have been made TV reports, manual workshops with the community's women and the exposition "Los murciélagos, un mito en nuestra cultura" (Bats, a myth in our culture) with a great people attendance.

The PCMM has future plans for this cave, as to work in another community and to run an evaluation of program's achievements. In other areas, the initial results of the evaluation of knowledge acquired and retained by the children through the pre – and post – exposure questionnaire – surveys indicate 70% retention knowledge about bats three years after exposure. Furthermore, new children entering the program in previously targeted schools, show a greater level of knowledge in pre – exposure questionnaires, indicating intra – community knowledge transfer from older to younger siblings. This, in turn, indicates that the process of bat conservation is being learned and adopted by the communities themselves as an activity of their own (Medellín, 2003).

Conclusions

Bats offer several ecosystem services, which are essential for natural environment and human welfare. Caves represent important sites where many bat species roost, mate, give birth and rear young. However, both bats and caves are facing threats often related with human activities and lack of information. Cueva del Diablo is a critically important cave for understanding, conservation, and recovery of an endangered, migratory pollinivorous bat species. This cave has already provided very important information about this little-known species. At least 50% of what is known about it comes from this cave.

Although a great effort has been maid to change these conditions, there is still a lot of work to do. Conservation of this and other caves and bats is urgently needed. This can only be conducted through collaboration across countries, disciplines, and sectors of society. It's necessary to change the general mistaken image people has about bats by sharing the information obtained in research, and environmental education programs had proved to be a good way to fulfill such task.

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