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Bats

of the Cañón de Somoto, Nicaragua

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Bats

of the Cañón de Somoto, Nicaragua

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1 Introduction

Background Information

The Monumento Nacional Cañón de Somoto (MNCS) is a geological formation and tourist attraction in the department of Madriz, Nicaragua. Located near the country's northern border 15 km west of the town of Somoto (Fig. 1), this striking canyon was discovered by a team of Czech and Nicaraguan geologists in 2004 and declared as a protected area in 2006 (Fonseca et al. 2008). The canyon itself is approximately 5 km long, comprising a 120 hectare core zone and 380 hectare buffer zone (Fig. 2).

The MNCS is notable for its steep walls (Fig. 3), which reach heights of up to 150 meters. The bottom of the canyon is comprised of rushing water: the end of the river Tapacalí, its confluence with the river Comalí, together which form the headwaters of the river Coco, the longest river in Central America. Many parts of the MNCS can be accessed only by floating down the river in inflatable rafts or inner tubes (Fig. 4). Although many tourists arrive with the intention of floating on the river, there are several trails within the park that traverse the tropical dry forest and scrubland that once characterized this area.

Justification

As ecotourism continues to grow in Nicaragua, this remarkable geological formation will play an increasingly important role as an attraction for tourists in northern Nicaragua. Although its striking rock formations are the main draw, this area could also be an important resource for native biodiversity, particularly in a landscape where much of the original forest has been converted to cattle pasture and agriculture.

Given the abundance of caves, rock crevices, and boulders in the MNCS, this area could be particularly important for bats, which rely on such structures for their roosting habitat. In the Parque Nacional Volcán Masaya, a large (>30,000 individuals) colony of mustached bats is a major tourist attraction and the subject of lucrative night tours in which park guards take visitors to observe the emergence of bats at sunset. Such bat tours could also be a draw for tourists to visit the MNCS, and with the presence of several small caves in the area, visitors may have the opportunity to observe bats up close when accompanied by a knowledgeable guide.

Objectives

1. Describe the bat fauna of the MNCS using captures and acoustic monitoring
2. Document the presence of caves, crevices, and boulders that act as roosting sites for bats
3. Educate local guides on the ecology and conservation of bats so they can share information with visitors and community members

2 Methods

Capture Methods

Thorough characterization of a Neotropical bat community requires the use of a variety of methods. Many bats can be captured using mist nets (Fig. 5), particularly those that fly close to the ground and rely less on echolocation for locating food (i.e., frugivores, nectarivores, insectivores and sanguivores of the family Phyllostomidae). Mist nets (2.8 m high by 6, 9, or 12 m long) are also moderately effective for capturing insectivores of the families Emballonuridae and Vespertilionidae in high-clutter environments (e.g., while foraging along streams with high vegetation cover). We therefore used mist nets to sample for bats along forest trails along the northern side of the canyon in areas of highly disturbed dry forest vegetation.

Mist nets alone are insufficient for capturing many insectivorous bats, for example Molossids (free tailed bats) that fly several meters above ground level. When flyways are relatively narrow, a triple-high mist net system (which stacks three mist-nets on top of one another to reach heights of up to 9 meters) can be used to capture higher-flying bats. We used a triple-high mist net system to capture bats in the bottom of the canyon, where the steep walls constricted flight to a narrow flyway (Fig. 6).

Although mist nets are extremely effective for capturing large numbers of bats in front of caves, they can be disadvantageous in such situations as the large numbers of bats emerging at dusk can overwhelm investigators, with bats being captured far more quickly than they can be removed. In such situations, harp traps can be advantageous because captured bats fall into a capture bag at the bottom until processing (Fig. 7), which reduces stress to captured bats. Harp traps are also more effective in capturing insectivorous bats, whose sophisticated echolocation abilities often allows them to avoid mist nets. We therefore used harp traps to capture bats in front of cave openings (Fig. 8)

Acoustic Monitoring

Many bats – particularly high-flying insectivores of the family Molossidae – cannot be adequately sampled by current capture techniques because they either fly above the levels at which mist nets are deployed, or because their highly sensitive echolocation systems allow them to sense and avoid mist nets. To adequately sample aerial insectivores, in Neotropical ecosystems it is necessary to use acoustic monitoring (MacSwiney et al. 2008). This process consists of using a recorder capable of detecting and recording the ultrasonic recordings of bats, and a related software to visualize the calls and quantify identifying parameters, such as minimum and maximum call frequency, frequency of maximum power, and pulse length.

To record and characterize bat echolocation calls, we used Anabat II detectors (Fig. 9) deployed passively to record echolocation calls. These units were set to automatically record all sounds above 5 kHz detected between 1800 and 0600 hours. Recordings were stored to an external CF card and visualized using Analook software. Calls were classified to family, or, when possible, species, via visual inspection and measurement of call parameters. Thus, characterizations are qualitative based on evaluation of call shape, minimum and maximum frequencies, and pulse length. Although calls can generally be assigned to family with a high degree of certainty, assignments to species may be more tentative as a result of overlap of call parameters, recording quality, and the availability of reference calls. We have previous experience analyzing bat calls (Williams-Guillen and Perfecto 2011), and we indicate a subjective measure of certainty of species identity is presented along with results. Due to technical issues affecting the deployment of Anabat units, we focus on species identification rather than relative measures of activity.

Cave Visits

To characterize the bat fauna in caves, we asked local guides to take team members to known caves and bat roosting sites. We then entered caves to make visual identifications of species and, when possible, we used harp traps in front of cave mouths to capture exiting individuals.

Educational Workshops

We conducted an educational workshop with local park guides, using a general curriculum developed by the Programa de Conservación de Murciélagos de Nicaragua (PCMN), of which two authors of the current report are founding members. The PCMN is dedicated to the conservation of Nicaragua's bats via research and outreach.

The content of the workshop included: a general review of mammalian biology; an informal survey of attitudes and beliefs about bats; a review of bat anatomy, behavior, and ecological importance; and a discussion of the bats of the Cañón de Somoto, their locations, and ecology.

Results 3

Bat Captures

We captured bats over five nights in early May, sampling a variety of habitats, including the river along the bottom of the canyon, its shorelines, secondary tropical dry forest, and disturbed areas near local communities. On one night we conducted captures near the main station in order to show local guides bats up close. On two nights, we conducted captures outside of caves using harp traps.

We captured a total of 78 bats of six species (Table 1). The majority (N=57) of bats captured were of the molossid species *Nyctinomops laticaudata* (Fig. 10), which were captured in the triple high mist net set over the river Coco (Fig. 6). Captures of this species are particularly notable because this is the first unequivocal confirmation of the presence of this species in Nicaragua (Barquez et al. 2008). The second most frequently captured species was *Desmodus rotundus* (Fig. 11), the common vampire bat, which likely feeds on the area's abundant livestock

We also captured three individuals of *Artibeus jamaicensis*, a large frugivorous bat common throughout Neotropical ecosystems (Fig. 12), *Sturnira lilium* and *Carollia perspicillata*, both small to medium-sized frugivores characteristic of disturbed areas, and *Glossophaga soricina*, a nectarivorous/frugivorous bat found in a wide variety of habitats. *Glossophaga* species were also frequently observed roosting in caves in the MNCS (Fig. 13). Finally, in front of one cave we captured a single individual of *Pteronotus parnelli*, a large insectivorous bat known to roost in caves.

Acoustic Monitoring

Due to technical problems with the Anabat recorders and microphones, we were unable to conduct acoustic monitoring during the entire study period, and many of the files recorded were of relatively low quality, which hampered recording. Recordings were made on a total of 30 nights between late April and late May 2013; on nine of those nights we had two functioning recorders, for a total of 39 recordinging nights (i.e., 12 hours of passive monitoring with Anabat). On 12 of those nights, we recorded bat calls. The number of calls recorded per night was highly variable, with zero recordings on most (N=28) nights, and over 1,000 calls on the night of April 30th, 2013.

Due to microphone malfunctions, most calls recorded were of poor quality (i.e., a high degree of background noise). However, we were able to identify calls belonging to a total of 21 morphospecies (Table 2). Most calls belonged to species from the families Emballonuridae and Molossidae, both of which forage in relatively open habitats (e.g., forest edges, above forest canopies, or at high altitudes. We also recorded several morphospecies of vespertilionids. Species of several families (e.g., Phyllostomidae, Natalidae) cannot be reliably distinguished via acoustic monitoring, thus their lack of representation among calls cannot be taken as evidence of absence in the area.

Among the sac-winged bats (Family Emballonuridae), we identified four morphospecies, including one (*Peropteryx microtis*) observed roosting in local caves (Fig. 14). All species identified would be expected in a relatively open wetland habitat such as MNCS.

Based on call morphology, we identified a minimum of 21 different call morphospecies (Appendix I), the majority of which were consistent with calls of bats from the families Emballonuridae and Molossidae, both of which forage in the open spaces characteristic of the MNCS. Of the 21 morphospecies, nine can be assigned to known species with high confidence and seven with moderate confidence (Table 2), due to the highly characteristic nature of these species' echolocation calls. Of these acoustic records of note include:

- *Mormoops megalophylla*, a species which has been documented at only one other site in Nicaragua, Masaya Volcano, and is otherwise unknown in Nicaragua (Dávalos et al. 2007)
- *Nyctinomops laticaudata*, documented for the first time in Nicaragua during this study via captures and acoustic monitoring
- *Molossops greenhali* (also known as *Cynomops mexicanus*), which has only been documented in Nicaragua's central highlands (Rodríguez and Miller 2008)

Cave Surveys

We located two caves with bats, both on the western end of the canyon on the river Tapacalí. The architecture of the first cave opening prevented us from capturing bats with the harp trap. However, we observed over 100 common vampire bats (*Desmodus rotundus*, Fig. 12), at least 50 nectar bats (*Glossophaga sp*.), and approximately 300 *Peropteryx macrotis*, a species of small insectivorous bat.

At the second cave, we had similar difficulties placing the harp trap in order to maximize captures, although we did capture seven bats of two different species (see above). In this cave, we also observed: approximately 200 common vampire bats (*Desmodus rotundus*); 200 short-tailed fruit bats (*Carollia sp*.); 3 hairy-legged vampire bats, a species usually found only in undisturbed habitat (Fig. 15); and approximately 30 nectar bats (*Glossophaga sp*.).

Both caves were difficult to reach, requiring the scaling of sheer cliff walls (Fig. 16) and the use of ropes to lift the harp trap to the cave mouth, which limits their use as tourist attractions. In both cases, the caves were dry; disturbance of sediments in dry bat caves can increase the probability of transmission of histoplasmosis, a fungal infection of the lungs that reproduces in animal urine. The inaccessibility of the caves, coupled with dry, dusty floors that favor the transmission of histoplasmosis, suggest that these areas are not suitable for development as ecotourism sites.

Environmental Education

A total of fourteen local guides attended the workshop on bat ecology (Fig. 17), during which we gave an informational talk on bat ecology, distributed educational posters on Nicaragua's bats, and demonstrated bat capture and identification to local guides. As a result of these workshops, we recommend further education of additional local guides with a focus on the bats unique to the zone, additional education on the ecosystem services provided by bats (e.g., pest control, pollination, seed dispersal), and follow-up training and evaluation of local guides on these topics.

4 Conclusions and Recommendation for Ecotoursim Development

The Monumento Nacional Cañon de Somoto hosts a diverse bat fauna, including the first documented population of the free-tailed bat *Nyctinomops laticaudata* documented in Nicaragua, and with the first documentation of *Molossops greenhali* and *Mormoops megalophylla* in this region of the country. Considering captures, observations in caves, and acoustic monitoring together, this relatively small area comprises feeding and roosting habitat for at 27 bat species (Appendix II).

Although the caves and crevices of the MNCS are not suitable sites for ecotourism (due to inaccessibility and potential for transmission of histoplasmosis in the dry soils forming the floor of bat caves), overall the area is extremely important for bat conservation, representing habitat for a variety of species that are unknown in other areas of Nicaragua. The diversity of bats can be a valuable tool to develop ecotourism in the area if the knowledge of local guides can be further developed. To promote bat-centered ecotourism, we recommend that local guides have access to inexpensive heterodyne bat detectors (e.g., http://www.batbox.com/batbox.html). In conjunction with previously described bat roosts, these detectors can be used to demonstrate to tourists the exits of bats from various small roosts, and this demonstration can serve as a basis for a more general discussion of bat ecology with a focus on the ecological importance of these nocturnal mammals.

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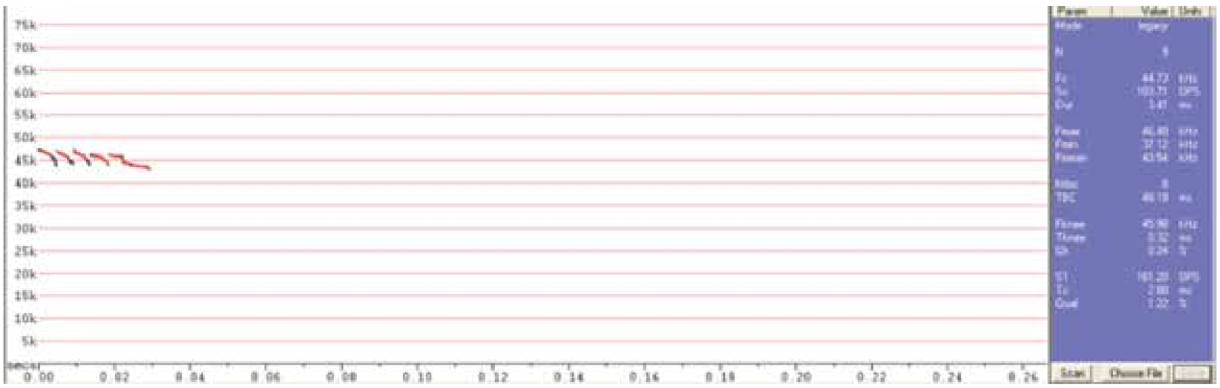
6 Appendixes

APPENDIX I.

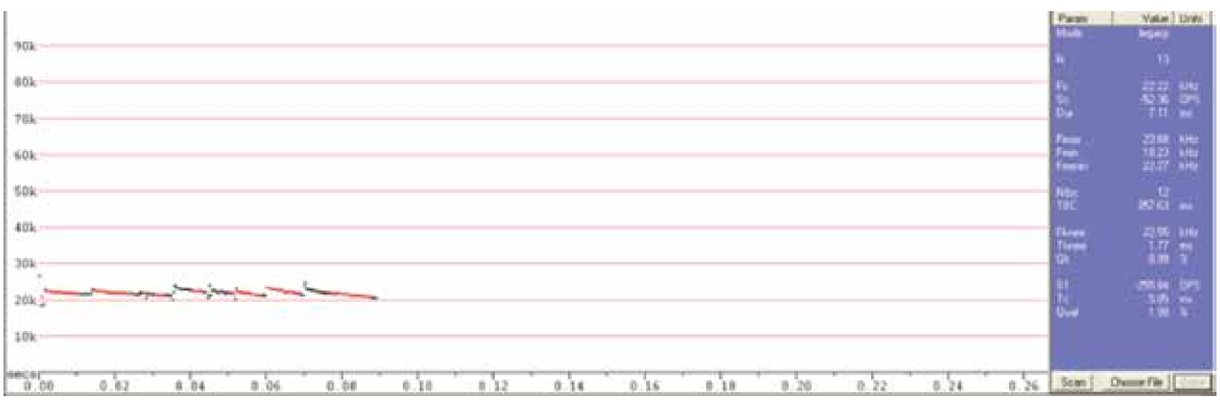
Representative calls of acoustic morphospecies identified from Cañón de Somoto, Nicaragua. All calls are visualized on a linear scale from 0 to 80 kHz on a time compressed horizontal scale; pixels representing background noise have been removed.

Emballonuridae

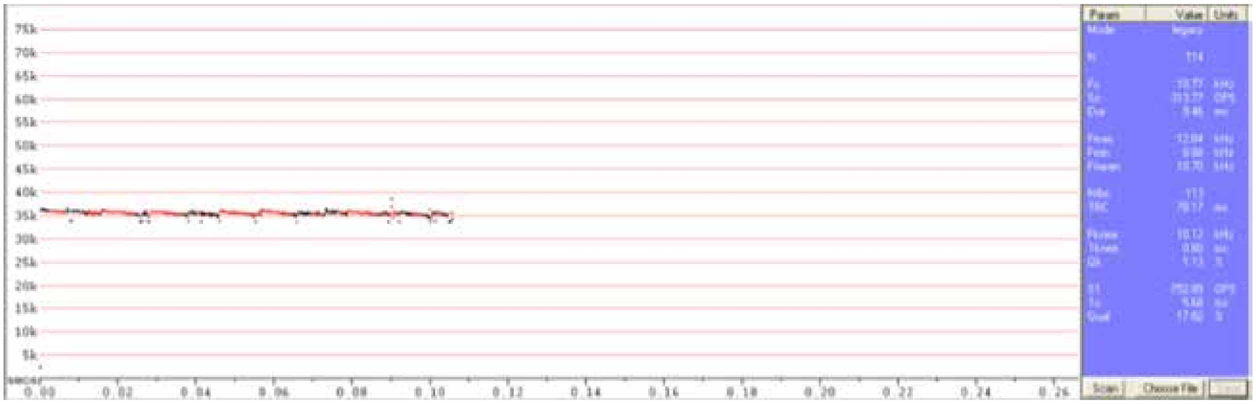
Balantiopteryx plicata



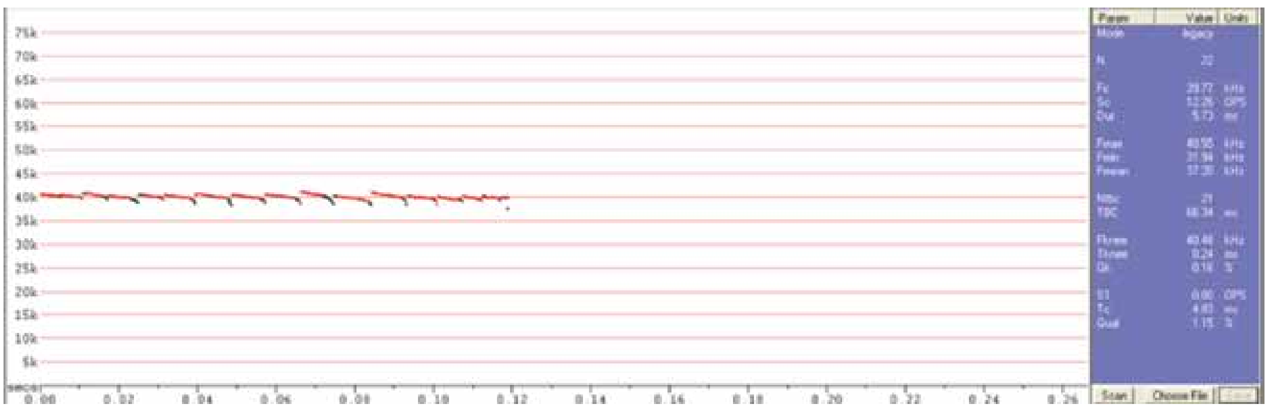
Dicludurus albus



cf. Peropteryx kappleri

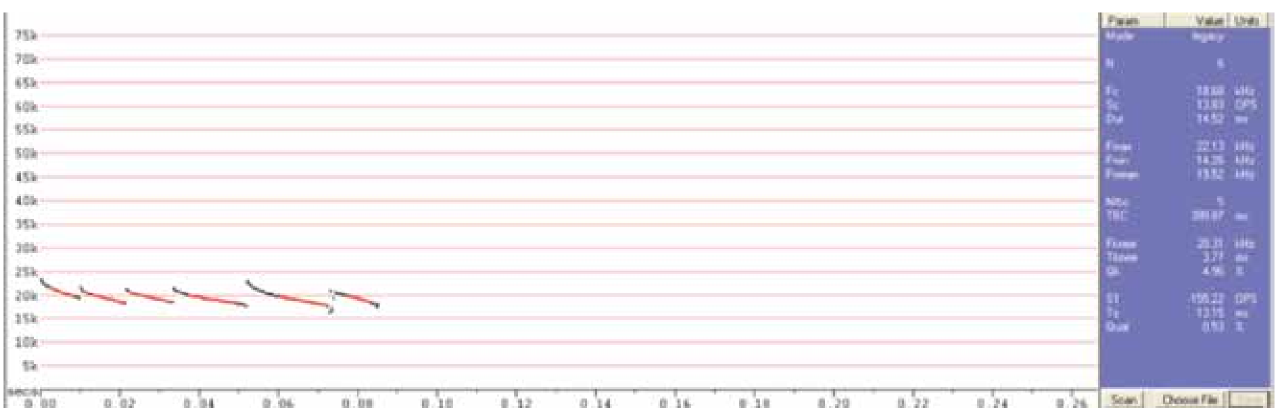


Peropteryx microtis

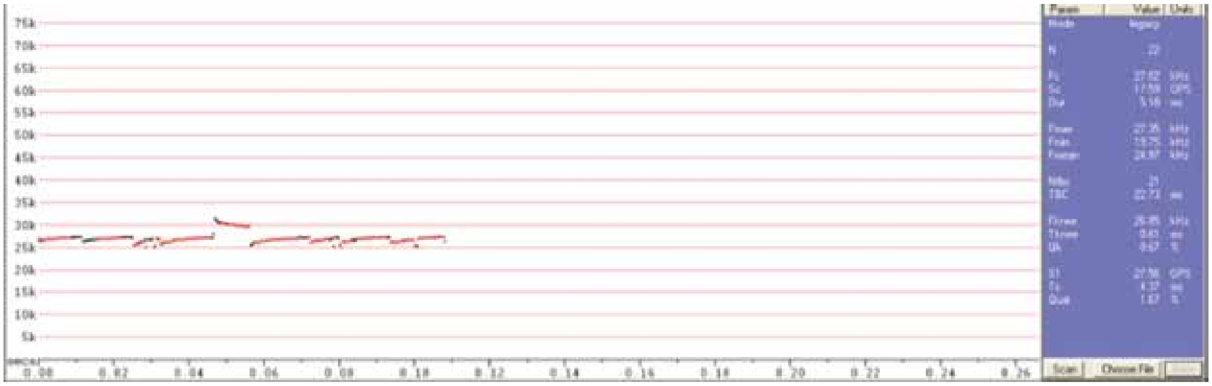


Molossidae

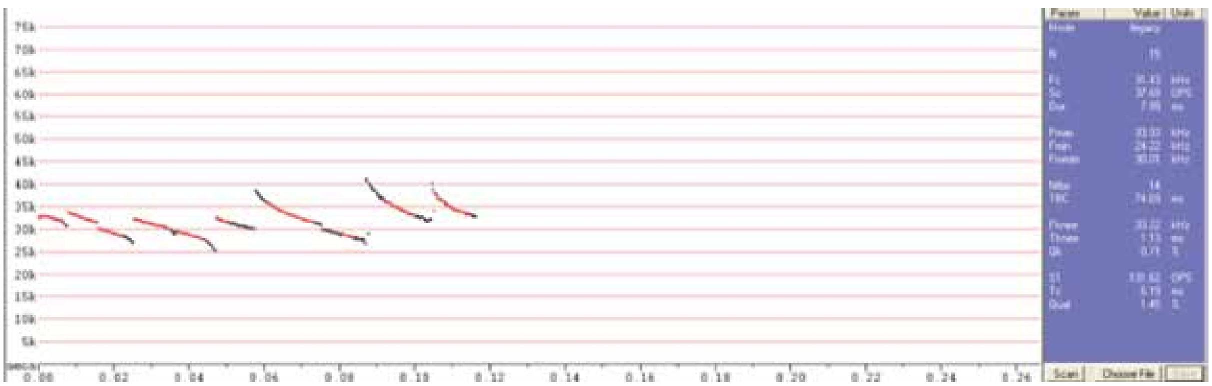
Eumops spp.



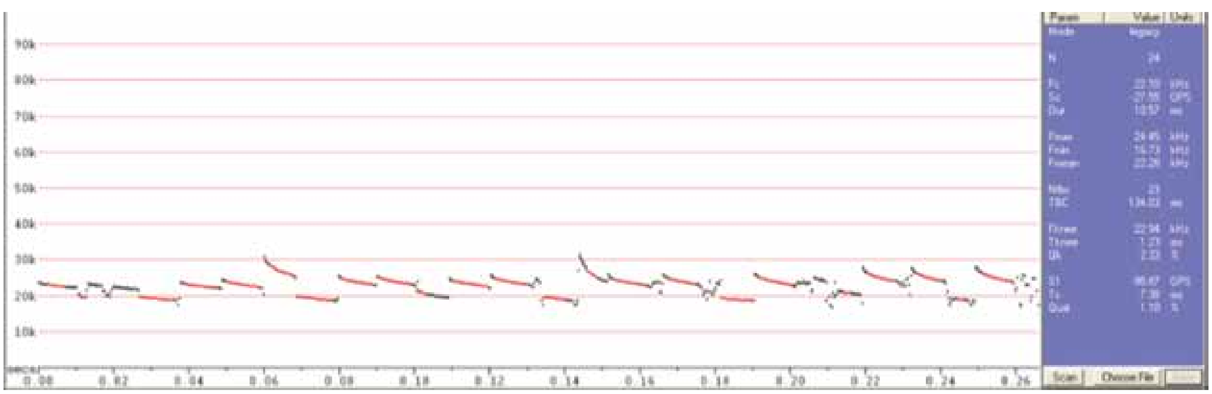
Molossops greenhali



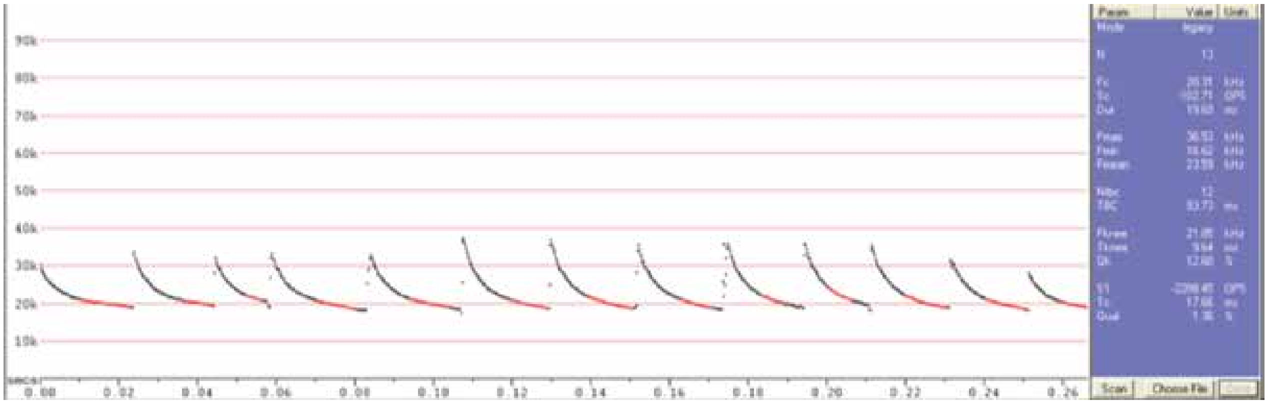
Molossus molossus



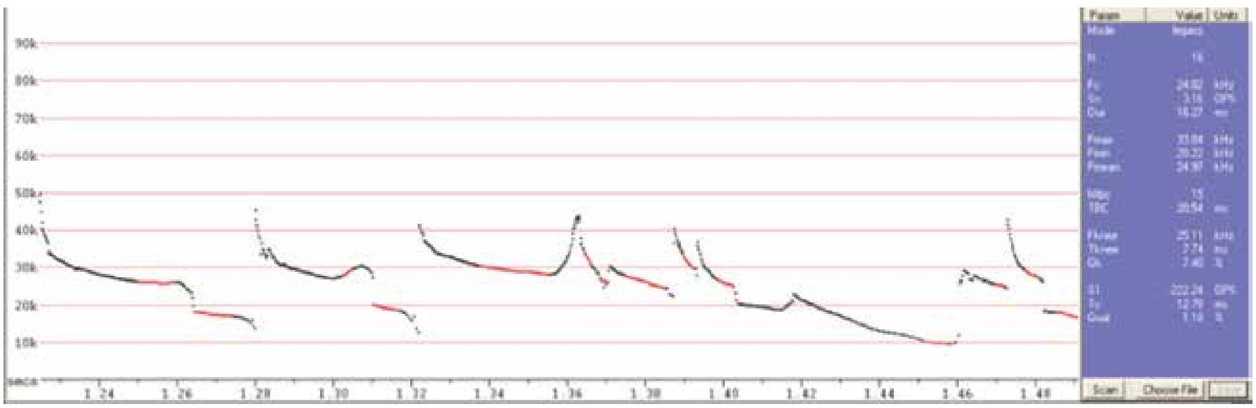
Molossus rufus



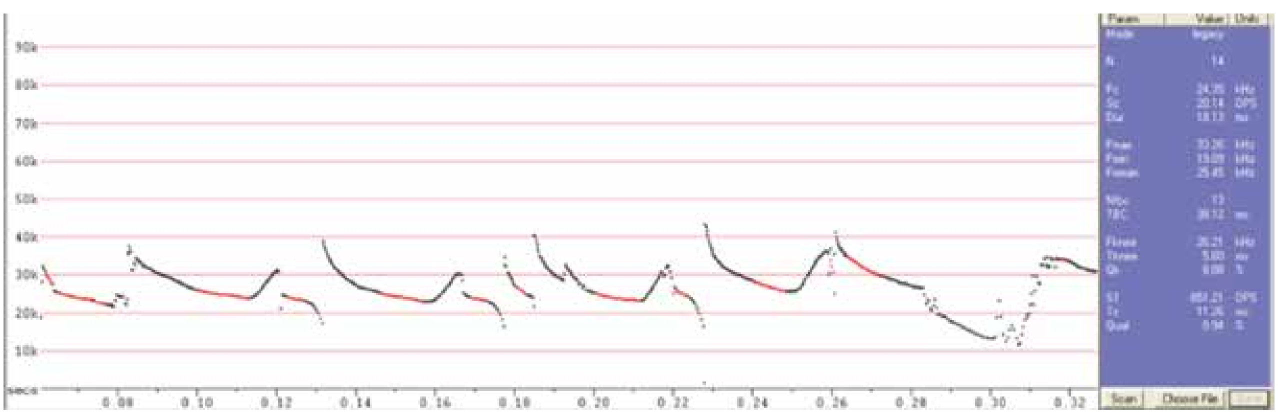
Nyctinomops laticaudata



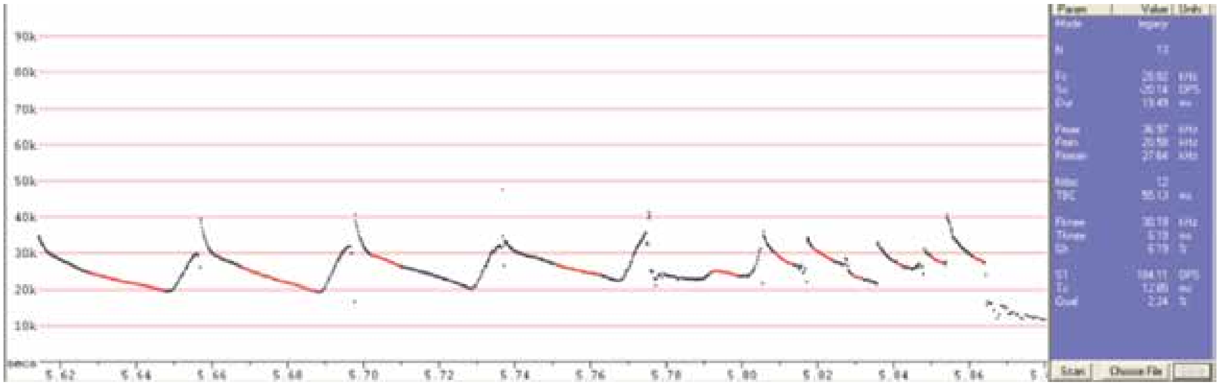
Molossidae species unknown (cf. Tadarida brasiliensis)



Molossidae species unknown (cf. Tadarida brasiliensis



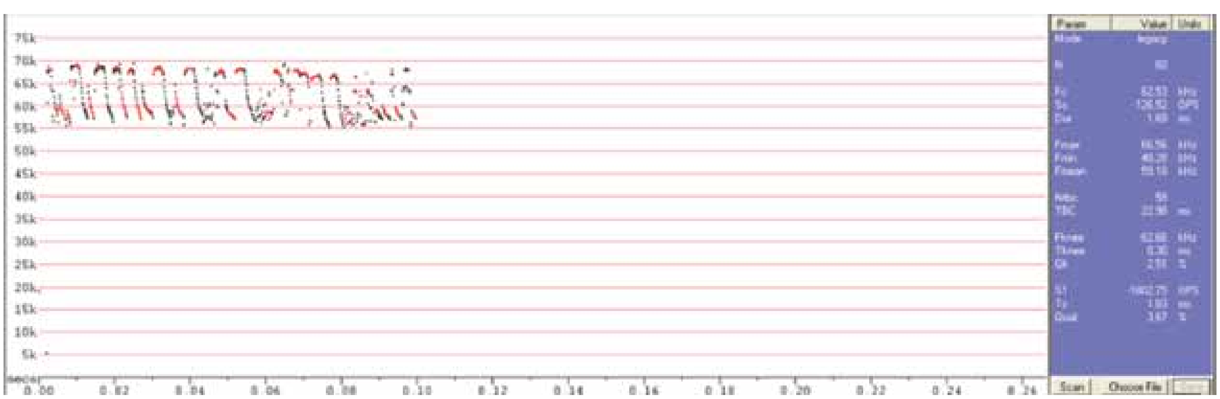
Molossidae species unknown (cf. Tadarida brasiliensis)



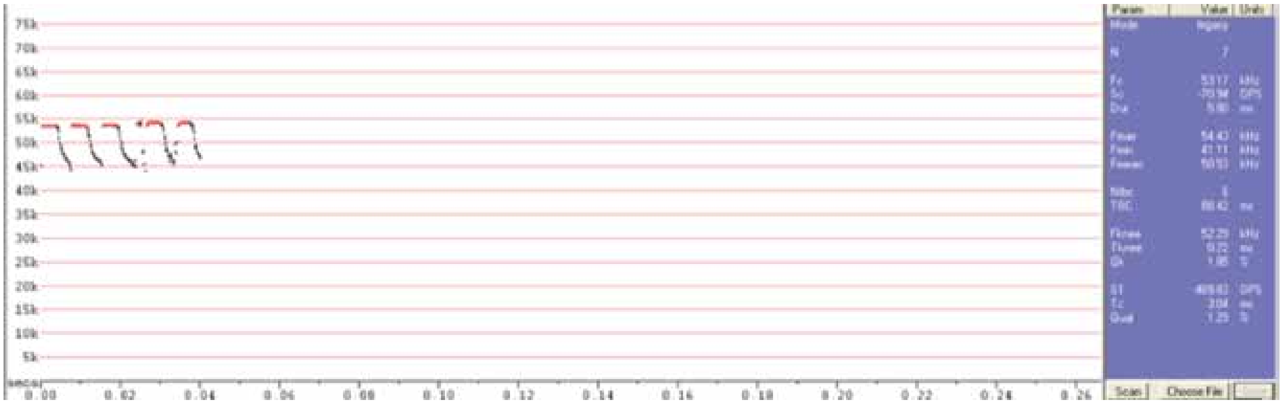
Molossidae

Mormoops megalophylla

Pteronotus davyi

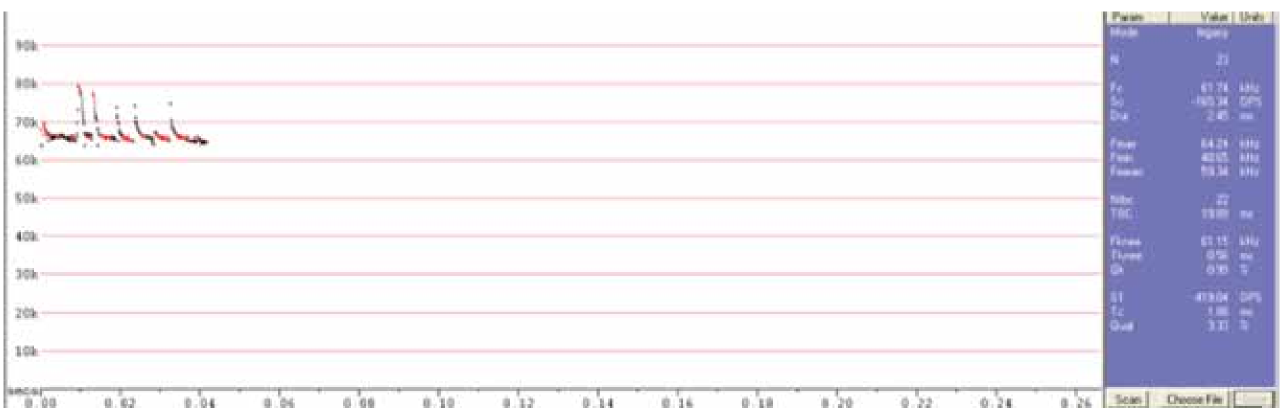


Pteronotus gymnonotus



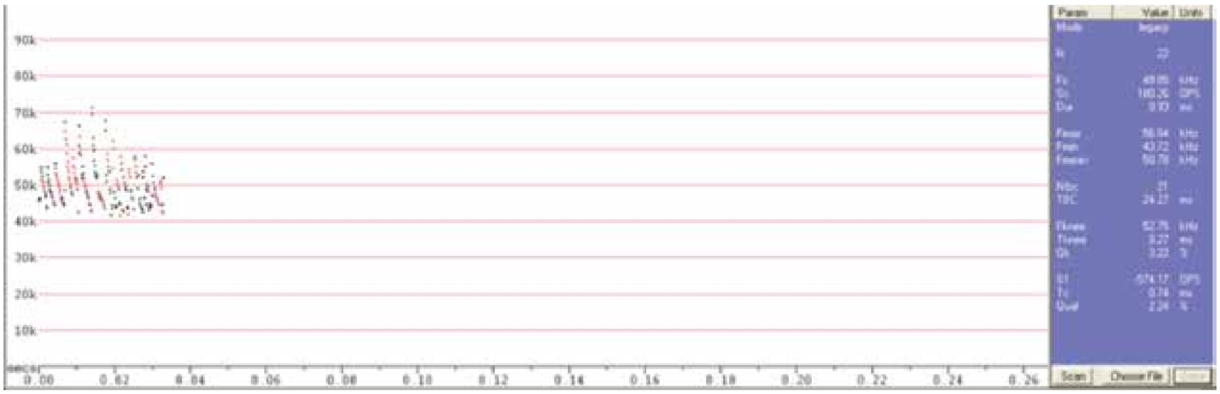
Pteronotus parnelli

Pteronotus personatus

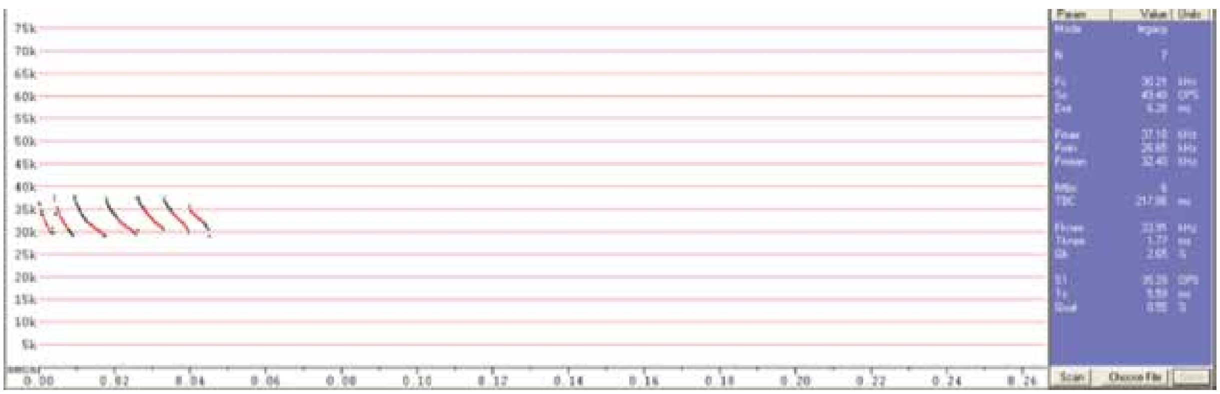


Vespertilionidae

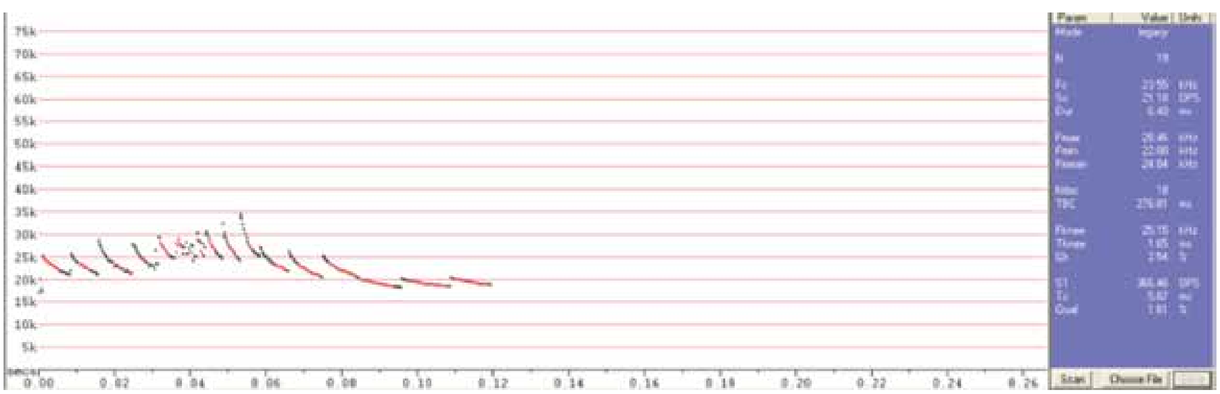
Bauerus dubiaquercus



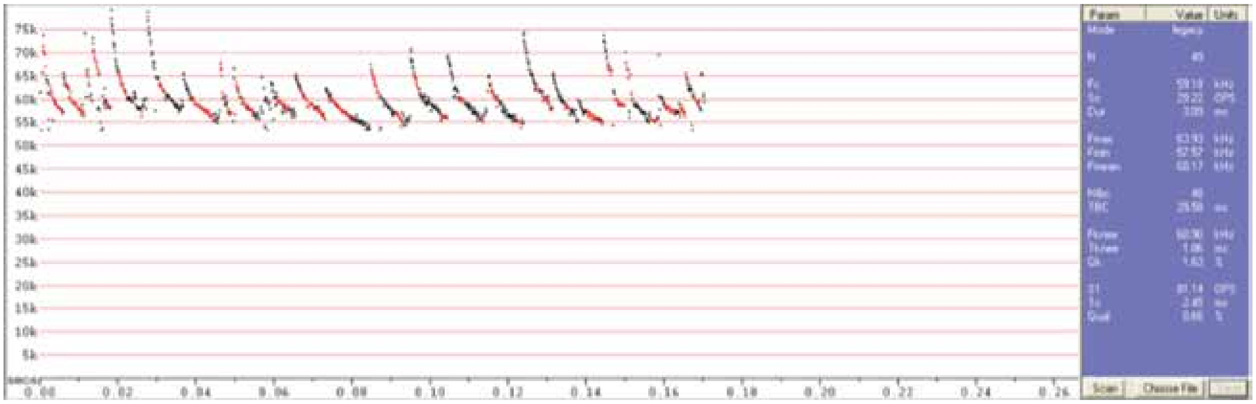
Eptesicus spp.



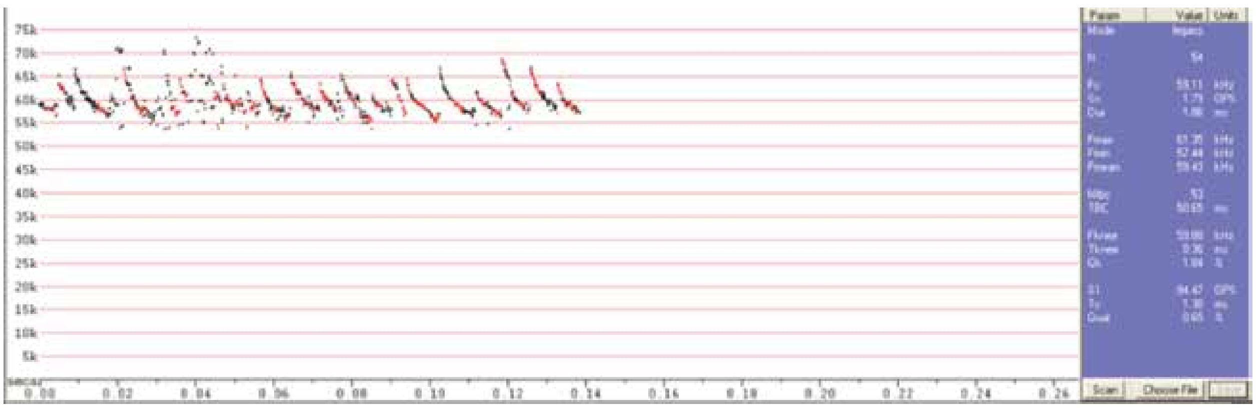
cf. Lasiurus cinereus



cf. Myotis elegans

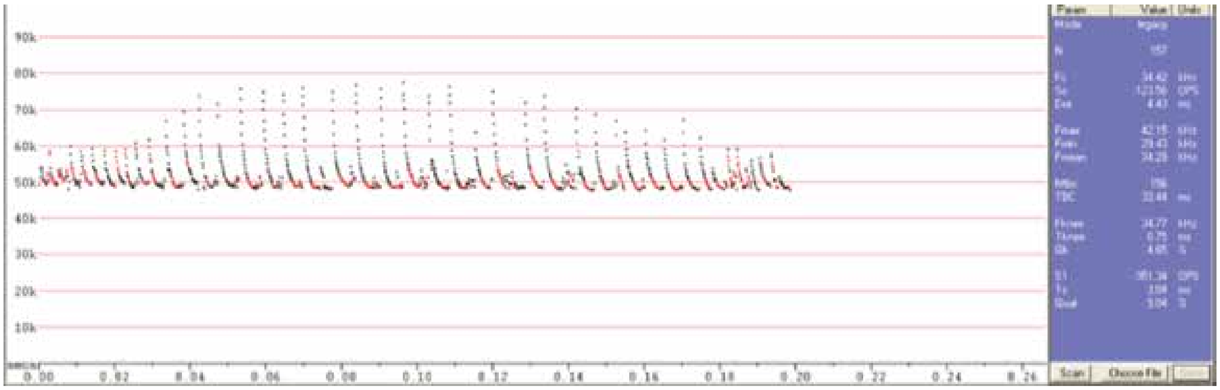


cf. Myotis keaysi



cf. Myotis nigricans

Rhogeesa tumida



APPENDIX II.

Species List of Bats, Monumento Cañon de Somoto, Nicaragua

Number	Family	Species	Captured	Recorded	Observed
1	Emballonuridae	*Balantiopteryx plicata*		X	X
2	Emballonuridae	*Diclidurus albus*		X	
3	Emballonuridae	*Peropteryx kappleri*		X	
4	Emballonuridae	*Peropteryx microtis*		X	
5	Molossidae	*Eumops spp.*		X	
6	Molossidae	*Molossups greenhali*		X	
7	Molossidae	*Molossus molossus*		X	
8	Molossidae	*Molossus rufus*		X	
9	Molossidae	*Nyctinomops laticaudata*	X	X	
10	Molossidae	*Sp. Indet cf. Tadarida brasiliensis*		X	
11	Mormoopidae	*Mormoops megalophylla*		X	
12	Mormoopidae	*Pteronotus davyi*		X	
13	Mormoopdae	*Pteronotus gymnonotus*		X	
14	Mormoopidae	*Pteronotus parnelli*	X	X	
15	Mormoopidae	*Pteronotus personatus*		X	
16	Phyllostomidae	*Artibeus jamaicensis*	X		
17	Phyllostomidae	*Carollia perspicillata*	X		X
18	Phyllostomidae	*Desmodus rotundus*	X		X
19	Phyllostomidae	*Diphylla ecaudata*			X
20	Phyllostomidae	*Sturnira lilium*	X		
21	Vespertilionidae	*cf. Bauerus dubiaquercus*		X	
22	Vespertilionidae	*Eptesicus sp.*		X	

Number	Family	Species	Captured	Recorded	Observed
23	Vespertilionidae	*Lasiurus cf. cinereus*		X	
24	Vespertilionidae	*cf. Myotis elegans*		X	
25	Vespertilionidae	*cf. Myotis keaysi*		X	
26	Vespertilionidae	*cf. Myotis nigricans*		X	
27	Vespertilionidae	*Rhogeessa tumida*		X	

APPENDIX III.

Tables

Table 1. Bats captured during five nights of sampling with mist nets and harp traps in the MNCS, May 2013.

Family	Species	Mist nets (disturbed areas)	Triple High nets (river)	Harp Traps (cave mouths)
Molossidae	*Nyctiniomops laticaudata*	0	57	0
Mormoopidae	*Pternotus parnelli*	0	0	1
Phyllostomidae (Carollinae)	*Carollia perspicillata*	1	0	0
Phyllostomidae (Desmotonitinae)	*Desmodus rotundus*	8	0	5
Phyllostimidae (Sternodomatinae)	*Artibeus jamaicensis*	3	0	0
Phyllostimidae (Sternodomatinae)	*Sturnira lilium*	2	0	0
TOTAL		**14**	**57**	**6**

Table 2. Bat species identified through acoustic monitoring, with assessment of confidence level of identification and notes on call identifications.

Family	Species	Confidence Level	Notes
Emballonuridae	*Balantiopteryx plicata*	Moderate	Although the calls have a characteristic frequency higher than that of P. microtis, with a more FM call, there is overlap between these species
Emballonuridae	*Diclidurus albus*	Moderate	Relatively short calls at 20-25 kHz could be confused with incomplete calls of Molossidae
Emballonuridae	*Peropteryx kappleri*	Moderate	Calls at approximately 35 kHz, which is somewhat higher than those observed in other areas of Central America

Family	Species	Confidence Level	Notes
Emballonuridae	*Peropteryx macrotis*	High	Frequently recorded calls similar to published reference calls, also observed in caves of the area
Molossidae	*Eumops sp.*	Moderate	All long calls with a characteristic frequency of 20 kHz or lower were characterized as Eumops, although these call parameters could overlap with Nyctinomops species.
Molossidae	*Molossops greenhali*	High	This species has a characteristic pattern of somewhat alternating upsweeping and downsweeping calls between 25 and 35 kHz
Molossidae	*Molossus molossus*	High	This species has a characteristic pattern of stepped calls between 30 and 40 kHz
Molossidae	*Molossus rufus*	High	This species has a characteristic pattern of stepped calls between 20 and 30 kHz
Molossidae	*Nyctinomops laticaudata*	Moderate	Members of this genus have long, moderately FM calls with a characteristic frequency 25-35 kHz; given that this species was captured, we have assigned calls with this characteristics to this species, although there can be some overlap with Eumops at lower frequencies at Lasiurus and Eptesicus at higher frequencies
Molossidae	*cf. Tadarida brasiliensis*	Low	This species has never been captured in Nicaragua, although its wide range and adaptability suggest that it should be expected in the country. This species is notoriously difficult to identify via acoustic monitoring due to its highly variable calls; however, many recordings were consistent with this species but not other molossids
Mormoopidae	*Mormoops megalophylla*	High	Although this species has only been documented at one other site in Nicaragua, its echolocation calls are distinctive
Mormoopidae	*Pteronotus davyi*	High	Highly characteristic echolocation calls are difficult to confuse with other species
Mormoopidae	*Pteronotus gymnonotus*	High	Highly characteristic echolocation calls are difficult to confuse with other species
Mormoopidae	*Pteronotus parnelli*	High	Highly characteristic echolocation calls are difficult to confuse with other species
Mormoopidae	*Pteronotus personatus*	Moderate	Highly characteristic echolocation calls are difficult to confuse with other species; however, calls corresponding to species are fragmentary and could potentially represent an unknown vespertilionid with a characteristic frequency of 65-70 kHz
Vespertilionidae	*cf. Bauerus dubiaquercus*	Low	Although many sequences recorded were consistent with this species, its calls can easily be confused with calls of other vespertilionids or even those of phyllostomids

Family	Species	Confidence Level	Notes
Vespertilionidae	*cf. Eptesicus sp.*	Low	Although many calls were consistent with Eptesicus species, they were often from low-quality recordings with low characteristic frequencies consistent with species rarely-encountered in Central America, such as E. fuscus
Vesptertilionidae	*cf. Myotis elegans*	Low	Other vespertilionids have calls with a characteristic frequency between 57-60 kHz, determining the exact species would likely require captures
Vesptertilionidae	*cf. Myotis keaysi*	Moderate	Several Myotis species have calls with characteristic frequencies of 55-58 kHz, although M. keaysi is one of the most frequently encountered
Vespertilionidae	*cf. Myotis nigricans*	Low	Other vespertilionids have calls with a characteristic frequency between 50-53 kHz, determining the exact species would likely require captures
Vesptertilionidae	*Rhogeesa tumida*	High	Although call parameters of other vespertilionids may overlap with this species, it is one of the most common vesper bats of Central America

APPENDIX IV.

Figure Captions

Figure 1. Location of the Monumento Nacional Cañón de Somoto in Nicaragua

Figure 2. Map of the Monumento Nacional Cañón de Somoto; map from Fonseca et al. (2008).

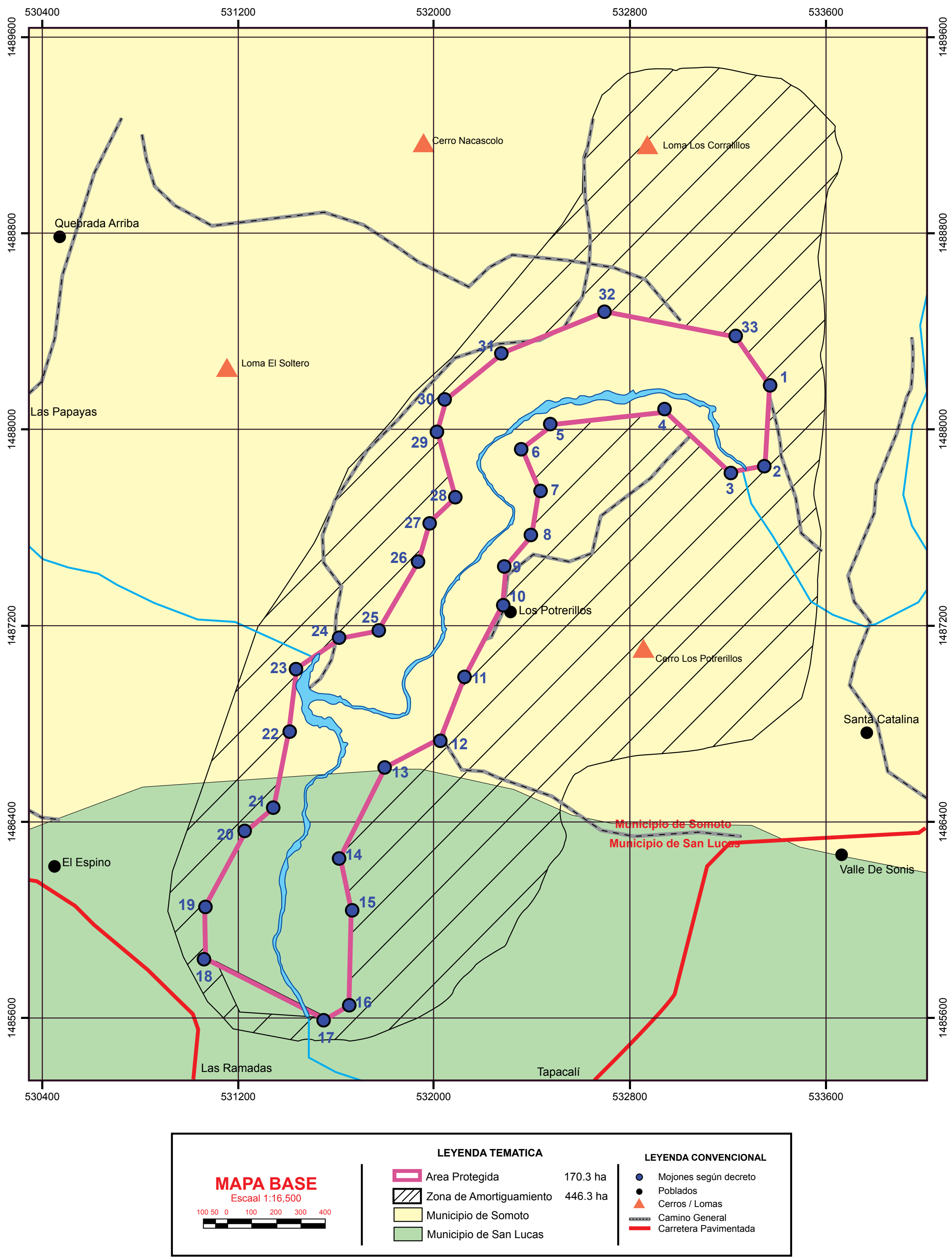


Figure 3. View of the Cañón de Somoto; ***photograph by Jack Fiallos.***

Figure 4. Travel along the MNCS via inner tube; ***photograph by Erica Frank***

Figure 5. Fine mesh mist nets can be used to capture bats flying at ground level; ***photograph by Merlin D. Tuttle.***

Figure 6. Triple-high mist net set up along the Río Coco to capture bats flying along the narrow flyway of the Cañón de Somoto; ***photograph by José Gabriel Martínez.***

Figure 7. A harp trap can be used to capture large numbers of bats at the mouths of caves or in narrow flight paths, they are also more effective for insectivorous bats that have sophisticated echolocation systems to sense prey and obstacles; ***photograph by Merlin D. Tuttle.***

Figure 8. We used harp traps to capture bats emerging from caves in the MNCS, as demonstrated by investigator Marlon Chávez; ***photograph by José Gabriel Martínez.***

Figure 9. Anabat detectors and associated Analook software can be used to record the ultrasonic calls of bats for evaluation of activity levels and, in some cases, species identifications; ***photograph by John Bullas***

Figure 10. *Nyctiniomops laticaudata*, captured foraging above the Río Coco and the first documented occurrence of this species in Nicaragua; ***photograph by José Gabriel Martínez.***

Figure 11. *Desmodus rotundus*, the common vampire bat (mother with nursing juvenile), a common species in the area; ***photograph by José Gabriel Martínez***

Figure 12. The Jamaican fruit bat, *Artibueus jamaicensis*, is found throughout disturbed and undisturbed areas of the Neotropics; **photograph by José Gabriel Martínez**

Figure 13. Nectar bats (*Glossophaga sp*.) roosting in a cave in the Cañón de Somoto; ***photograph by José Gabriel Martínez.***

Figure 14. *Balantiopteryx plicata* is a small insectivorous emballonurid that roosts in caves and crevices; ***photograph by José Gabriel Martínez***

Figure 15. The hairly legged vampire bat *(Diphylla ecaudata)* feeds exclusively on the blood of birds and is rare in disturbed areas; ***photograph by José Gabriel Martínez.***

Figure 16. To reach bat caves on the river Tapacalí, one must scale sheer cliff walls; ***photograph by Kim Williams-Guillén.***

Figure 17. Workshop to educate local guides on bat ecology and conservation; ***photograph by José Gabriel Martínez***

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