

Report of the bat Conservation and Management Workshop Training

TUTTLE ET AL. 2013.

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RESUMEN: Casi la mitad de los mamíferos terrestres en Sudamérica son murciélagos, y en muchas localidades ellos constituyen la mitad de la diversidad de mamíferos. En Latinoamérica los murciélagos llenan muchos nichos alimenticios, y su pérdida puede comprometer numerosos servicios ecosistémicos críticos. Sin embargo, en la mayoría de Latinoamérica, incluyendo Paraguay, los murciélagos son temidos y sus beneficios poco apreciados. Por lo general los murciélagos benéficos son eliminados y sus guaridas permanentemente destruidas, poniendo en riesgo la salud ambiental y económica.

Otra amenaza importante para los murciélagos, y otra fauna silvestre, es la pérdida de hábitat por conversión a la agricultura y asentamientos humanos. Guyra Paraguay ha reconocido estas amenazas y tomado pasos importantes para promover la conservación de la vida silvestre y sus hábitats en Paraguay, rápidamente dándose cuenta de la importancia de incluir a los murciélagos en sus planes futuros.

Una de las áreas menos conocidas en Paraguay, respecto a la fauna de murciélagos, es el ecosistema del Pantanal, con 17 especies reportadas anteriormente. Mayor información es necesaria para comprender el ensamblaje de murciélagos en ese lugar. En particular, el uso de nuevas técnicas más allá del uso tradicional de las redes de neblina (p.e. detectores ultrasónicos, redes de dosel) pueden aumentar el número de especies. Uno de los mayores impedimentos para la conservación de la naturaleza en Paraguay es el escaso número de personal apropiadamente entrenados. Para poder tener un impacto en la conservación de los murciélagos, el entrenamiento debe ir más allá de las técnicas de inventarios, debe incluir también información sobre la importancia de los murciélagos.

Del 1 al 15 de Septiembre de 2009, Guyra Paraguay organizó un taller junto a Bat Conservation International (Merlin D. Tuttle, USA), Centro de Biodiversidad y Genética (Luis F. Aguirre, Universidad Mayor de San Simón, Bolivia), USDA Forest Service (Ted Weller) y el Programa para la Conservación de los Murciélagos de Bolivia (Kathrin Barboza). Los objetivos del taller fueron el de entrenar a biólogos y técnicos Paraguayos en técnicas requeridas para el estudio, monitoreo y conservación de murciélagos. Los participantes aprendieron sobre los valores de los murciélagos para los ecosistemas y la economía humana, así como en la manera de identificar especies y realizar inventarios de campo. El entrenamiento de campo incluyó la enseñanza en el uso de redes y trampas para capturar murciélagos, desarrollo de capacidades en manipuleo e identificación de especies y exponerlos a métodos acústicos para el inventario de especies difíciles de capturar.

El taller empezó con una serie de charlas en un seminario llamado "Introducción a la Conservación y el Manejo de murciélagos" presentadas por Merlin Tuttle, Luis F. Aguirre y Kathrin Barboza en el auditorio de la Facultad de Ciencias Veterinaria de la Universidad Nacional de Asunción (UNA). Se contó con más de 90 participantes. Esa misma noche se visitó la cueva de Tobati donde se demostraron técnicas para la captura de murciélagos y aspectos generales de conservación de murciélagos. Los siguientes días, con un extraordinario ▶

ABSTRACT: Bats are a critical component of Latin American biodiversity, often accounting for nearly half of mammal species. Loss of their pollination, seed dispersal and insect control services greatly compromises ecosystem health. Nevertheless, most Latin Americans mistakenly view all bats as vampires and target them for eradication, often permanently destroying essential roosting habitats, from hollow trees to caves, including in Paraguay. In recognition of these threats, Guyra Paraguay and the U.S. Forest Service International Programs, collaborated with Bat Conservation International (Merlin D. Tuttle, USA), Centro de Biodiversidad y Genética (Luis F. Aguirre, Universidad Mayor de San Simón, Bolivia), USDA Forest Service (Ted Weller), and the Bolivian Bat Conservation Program (Kathrin Barboza). The workshop was held September 1-15. The objectives were to train Paraguayan biologists in the techniques required to study, monitor and conserve bats. Participants learned of bat values to healthy ecosystems and human economies as well as how to identify bats and conduct field surveys. Field training included instruction in varied mist netting and trapping techniques to capture bats, development of bat handling and identification skills and exposure to acoustic methods for surveying bats that are difficult to capture. Field training was concentrated in the Pantanal, one of the least known ecosystems in Paraguay relative to bats. Training centered on the town of Bahía Negra and the Tres Gigantes Biological Reserve.

The workshop began with a series of lectures in a seminar entitled "Introduction to Bat Conservation and Management" presented by Merlin Tuttle, Luis F. Aguirre and Kathrin Barboza at the facilities of the Universidad Nacional de Asunción (UNA), Facultad de Ciencias Veterinarias. There, more than 90 people attended the lectures. Later that evening participants visited Tobati cave where instructors explained about trapping, netting and detection techniques, vampire bat roost recognition, and bat conservation. Later, with an outstanding group of 10 participants, a trip to Bahía Negra and Tres Gigantes Biological Reserve was conducted to provide in-depth field training. During eight days of bat surveys at Bahía Negra and Tres Gigantes, we were able to confirm the presence of 14 species, and we acoustically detected the presence of at least 3 others (but could not assign them to species), resulting in a total of at least 17 species of bats (31% of the species in Paraguay), five of them being new for the department of Alto Paraguay.

Following the completion of the workshop the instructors had time to discuss ideas for further bat work in Paraguay. We suggest building on this initial training to create a bat conservation program for Paraguay in support of public education, additional training, use of artificial roosts, and conduct research activities oriented to bat conservation.

KEY WORDS: Bats, Chiroptera, Paraguayan Pantanal, Bat research techniques and inventories.

grupo selecto de 10 participantes, se realizó el viaje a Bahía Negra y a la estación biológica Tres Gigantes para dar un curso más profundo sobre inventarios, técnicas de colecta y conservación de murciélagos. El trabajo incluyó la práctica con redes de neblina, trampa arpa, trampa de dosel, monitoreo acústico y búsqueda de guaridas. Los participantes aprendieron sobre la importancia del uso de técnicas diferentes simultáneas para realizar un inventario completo. Se formaron dos grupos y realizaron un proyecto cada uno durante los últimos días del curso, el cual fue defendido al final del mismo.

Luego de ocho días de inventarios y trabajo en Bahía Negra y Tres Gigantes, se pudo confirmar la presencia de 14 especies y detectar la presencia de al menos otras 3 por medios acústicos, para hacer un total de al menos 17 especies de murciélagos (31% de las especies del Paraguay), cinco de ellas nuevas para el departamento de Alto Paraguay.

Al final del taller, los instructores discutieron ideas para trabajos futuros con murciélagos en Paraguay. Las ideas se centraron en capitalizar el momento creado en el taller, tanto en el simposio como en el trabajo de campo. Entre algunas de las posibilidades para desarrollar en el futuro se encuentra la creación de un Programa para la Conservación de los Murciélagos del Paraguay, actividades de educación, más entrenamiento, uso de guaridas artificiales y el desarrollo de investigación orientada a la conservación de los murciélagos.

PALABRAS CLAVE: Murciélagos, Chiroptera, Pantanal Paraguayo, técnicas de investigación inventarios de murciélagos.

BACKGROUND

Nearly one third of all terrestrial mammals in South America are bats and, in many locations, they constitute half of mammalian diversity (Simmons 2005). Latin American bats fill a wide variety of feeding niches (Aguirre 2007, Patterson *et al.* 2003), and their loss can compromise critical ecosystem services, making an improved understanding of their conservation status vital (Kalka *et al.* 2008, Williams-Guillen *et al.* 2008), A Latin American species (*Tadarida brasiliensis*) saves commercial agriculture millions of dollars annually in reduced need for pesticides (Cleveland *et al.* 2006), and a recent study in Mexico suggests additional values there (Williams-Guillen *et al.* 2008).

Nevertheless, in most parts of Latin America including Paraguay, bats are often vilified and feared, and their benefits underappreciated. The presence of vampire bats is one of the root causes of misunderstanding and malevolence. Vampire bats can have negative economic impacts on cattle and poultry farming and therefore are frequent targets of persecution and eradication efforts by ranchers, government health officials, and the general public who conduct major campaigns to destroy them and their habitat, especially their roosts. Often, large numbers of beneficial bats are mistakenly killed, and their roosts permanently destroyed, at great risk to ecosystem and economic health. Another important threat to bats and other wildlife is loss of natural habitats through agricultural conversion and human settlement. Guyra Paraguay has recognized these threats and taken important steps to promote conservation of wildlife and its habitats in Paraguay. Through its programs to acquire and maintain reserves, restore habitat, and highlight the splendor and natural beauty of habitat and wildlife species, Guyra Paraguay has provided an important foundation for wildlife conservation. Although their initial wildlife programs have focused mostly on birds, herpetofauna and large mammals, Guyra Paraguay was quick to realize the importance of including bats in their future plans.

Paraguay occupies 406,752 km² in the central part of South America, Between Argentina, Brazil and Bolivia (Fig. 1). It has a subtropical and continental climate with hot, wet summers and cool, dry winters, with a mean annual temperature ranging from 21–26 °C and precipitation ranging from 400–1800 mm. Paraguay is bisected by the Tropic of Capricorn, occurring at a temperate-tropical interface. The natural habitats are classified into seven separate biomes (Fig. 1). During the late 1990's, the bat fauna of Paraguay was the subject of considerable academic attention and as a result 54 species are known (López-González 2005), primarily from sampling at 25 locations throughout the country (Fig. 1).

One of the least known areas in Paraguay, regarding bat faunas, is the Pantanal ecosystem (Matogrosense [MG] phytogeographic zone), with only two sampling sites out of the 26 surveyed in Paraguay (Fig. 1). In the Pantanal (MG biome), 17 species were reported by López-González (2005), corresponding to about a third of the total Paraguayan bat fauna but more information is needed to improve understanding of the bat assemblage in this area. In particular, use of new techniques beyond traditional mist netting (i.e. echolocation detectors, canopy

nets, etc.) can expand the number of species detected.

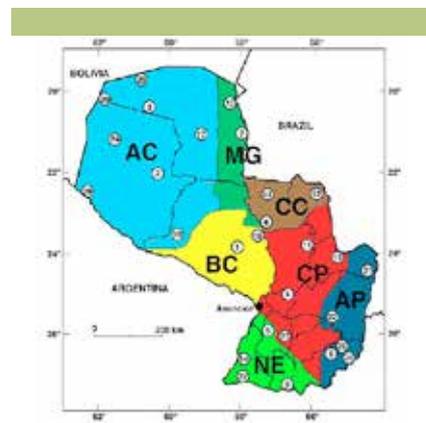


Fig. 1. Map of the locations of the 25 collection sites (circled numbers) throughout Paraguay. Alphabetic codes refer to each of 7 biomes: Matogrosense, MG; Alto Chaco, AC; Bajo Chaco, BC; Campos Cerrados, CC; Central Paraguay, CP; Alto Paraná, AP; Ñeembucú, NE (From Willig *et al.* 2000).

To date the species richness of bats in Paraguay, and the role they play in ecosystems, has not been fully appreciated. One of the primary impediments to nature conservation in Paraguay, particularly of bats, is the scarcity of properly trained personnel. To be significant for bat conservation, training must go beyond survey techniques. It also must include information on why bats are the important.

OBJECTIVES

The objectives of this workshop were to train Paraguayan biologists in the techniques required to study, monitor and conserve bats. Participants learned of bat values to healthy ecosystems and human economies as well as how to identify bats and conduct field surveys. Field training included instruction on use of mist nets and traps to capture bats, development of bat handling and identification skills and exposure to acoustic methods for surveying bats that are difficult to capture.

DESCRIPTION OF ACTIVITIES

Activities in Asunción: Caves discussion

Activities in Paraguay began with a gathering at Guyra Paraguay headquarters and a meeting with representatives of “Fundación Cavernas de Paraguay-Conozco Protejo” and “Federación Paraguaya de Espeología”. There, representatives described their activities in several caves in Paraguay. Most of the caves, located in the Campos Cerrados biome in NE Paraguay (Fig. 1), showed signs of human intervention and disturbance due to uncontrolled tourist activities. Both institutions noted the need for bat surveys and conservation activities in those areas to protect bats and their cave habitats. One presentation included a photo of the rare carnivorous

bat (*Chrotopterus auritus*) in a cave. This is one of Latin America's least known species, and it is especially susceptible to human disturbance.

It was clear that any Paraguayan bat conservation program should include an early assessment of caves and cave-dwelling bats. Some Latin American caves support tens of thousands, even millions of bats in single caves, making their protection a key factor in bat conservation. At this time, no one knows whether or not such cave populations exist in Paraguay. However, when poorly informed vampire control activities are initiated, the largest cave-dwelling bat populations are normally among the first to be targeted. We were delighted to have several students of veterinary medicine among our workshop participants, and we hope these will have substantial impact on any vampire control initiatives of the future. During our workshop training at Universidad de Asuncion, we illustrated how to identify evidence of beneficial versus vampire bats in caves and were able to reinforce this with an evening demonstration at a real vampire bat roost in Tobati Cave.

Workshop at UNA and visit to Tobati Cave

On September 3rd a one day-workshop entitled "Introduction to Bat Conservation and Management" was conducted at the facilities of the Universidad Nacional de Asunción (UNA), Facultad de Ciencias Veterinaria (Fig. 2). There, more than 90 people attended the lectures, far surpassing organizer's expectations.

Lectures started with an introduction to bat diversity, values and conservation needs worldwide (in Spanish) by Dr. Merlin Tuttle. Dr. Tuttle highlighted several Paraguayan species and illustrated the power of local education and collaboration in conserving key bat populations.

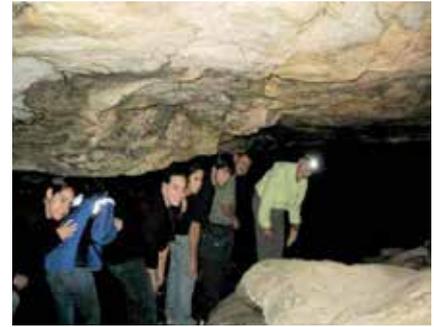
Dr. Luis F. Aguirre next provided more detailed information on bat taxonomy, ecology and behavior, all related to the importance of bat conservation in the region and the country. Participants were also introduced to the Bolivian Bat Conservation Program (PCMB), its activities and structure as a possible model for Paraguay. He also highlighted a recent initiative (i.e. Latin American Network for Bat Conservation, RELCOM) which promotes coordination and collaboration opportunities between existing programs and those that will be formed.

Kathrin Barboza provided an excellent introduction to bat acoustic ecology and echolocation and how such information can be used to survey and monitor populations. She also introduced basic concepts on how to conduct studies of habitat use, ecology and behavior using ultrasound.

After the lectures, a DVD produced by Bat Conservation International on Control of "Vampire Bats in Latin America", was presented and a lively discussion ensued regarding the importance of including vampire bat education and control in conservation programs. Methods for proper surveillance and monitoring of rabies in vampire bats were also discussed.



Fig. 2. Lectures at Universidad Nacional de Asunción and visit to Tobati cave.



Later that evening, more than 30 of the participants reconvened for a visit to a nearby cave near the town of Tobati. There, instructors demonstrated the use of different techniques to survey bats including mist nets in the surrounding habitat, a harp trap at the entrance of the cave and recording of bats using bat detectors (Fig. 2). Although no bats were captured (likely due to full moon conditions) participants were able to see vampire bats inside the cave and learn how to discriminate vampire bat feces from that of insectivorous bats. Also, some participants that had surveyed the area prior to our work exhibited specimens of bats that had been preserved in alcohol.

These specimens were important to illustrate differences in bat families (i.e. Phyllostomidae, Vespertilionidae and Molossidae). From the records of acoustic monitoring it was possible to determine that at least 3 species were present in the area including yellow bats (*Lasiurus ega*) and at least 3 different species from the family Molossidae.



Fig. 3. Tree-hollow used by lesser fish-eating bats (*Noctilio albiventris*) in Bahia Negra, Alto Paraguay.

Bahía Negra: Roost search

A three-day survey of bat roosts was conducted in the town of Bahia Negra. This allowed us to demonstrate several kinds of roosts including in hollow trees and in both occupied and abandoned buildings. During the search of roosts we found several *Tabebuia* trees containing the Lesser Fish Eating Bat (*Noctilio albiventris*) and some Free Tailed bats (Molossidae) (Fig. 3). Although we were able to locate several hollow trees currently occupied by bats, many more showed signs that local residents had burned them to kill vampires. None of these roosts actually contained vampires. As we were able to clearly illustrate, the targeted roosts were used only by highly beneficial insect-eating bats.

Bats, or sign of bats (i.e., guano, staining) were found in a large proportion of the buildings surveyed. Some of them were abandoned (Police headquarters and in the Military station) and others which were still occupied by humans (Hospital and houses). In the Military station a single individual of the Common Vampire Bat (*Desmodus rotundus*) was found (Fig. 4). Other species living in buildings, or using them as night roosts, in the area, confirmed later by mist netting were the Riparian Bat (*Myotis riparius*), the Mexican Free Tailed Bat (*Tadarida brasiliensis*), Pallas's Mastiff Bat (*Mollosus mollosus*) and the Lesser Fish Eating Bat (*N. albiventris*). A note of caution about the *T. brasiliensis* record: some

differences in external morphology (lack of clear presence of grooves in the lips) between the individual and the identification keys were noted, making species identity ambiguous. An individual was preserved in alcohol to confirm species identify using skull and tooth characters. Recordings of its echolocation calls were consistent with *T. brasiliensis* calls from North America but, due to extreme variability in call characteristics of this species and others in the family Molossidae, we cannot use call characteristics to confirm identity of this individual.



Fig. 4. Common vampire bat (*Desmodus rotundus*) blood pool under its roosting site in the military installation in Bahia Negra.

The search for roosts was a very important survey activity. Several species were detected only by this method (i.e. *Desmodus rotundus* and *Tadarida brasiliensis*) demonstrating that roost surveys can be a valuable tool in this and other areas, especially where human structures are available. The search for roost structures also provided an important opportunity to interact with the local populace and engage them in discussions about the beneficial roles that bats play in the environment. Through our conversations with local people we tried to demonstrate to workshop participants how such efforts can simultaneously accomplish 2 tasks: locating important roosts and educating the public. Both are important components of a conservation program.

Training in Mist Netting

During the stay in Bahia Negra, we also searched for suitable places to conduct mist netting. Most of the area, as part of the Pantanal ecosystem, is difficult to mist net because few natural corridors exist where bat activity is concentrated. We located two small ponds near the intersection between Line 1 and Line 2 (both lines are roads that lead to Central Chaco) where we set up mist nets (Fig. 5). This was the first opportunity to explain to demonstrate how to properly set mist nets over a pond so as to intersect the flight path of drinking or feeding.



Fig. 5. Placing mist nets over ponds near Bahia Negra, Alto Paraguay.

During two nights of mist netting over the ponds we were able to collect 11 Yellow Bats (*Lasiurus ega*). Although, diversity of animals captured was less than we'd hoped, this represents an outstanding number of records of a species that is normally quite difficult to capture. In combination with the records acquired at Los Tres Gigantes we demonstrated that this area is especially important for this species.

Mist netting was also conducted near the roosting trees and buildings within Bahia Negra. This provided excellent hands-on experience for the workshop participants on how to set up and remove bats from mist nets. All of them were instructed on methods of handling bats comfortably and confidently so as to minimize risk of harming bats or being bitten.

Whenever possible, we introduced local people to bats and their importance, emphasizing that the vast majority are not vampires. Once they had received this information their attitudes towards bats were clearly changed seeing them as important and fundamental allies.

Lecture at EcoClub

Upon return from Los Tres Gigantes, we were invited to give a presentation at the radio station managed by Eco-Club. Dr. Tuttle gave a lecture introducing the importance of bats to a small group from Bahia Negra (Fig. 6). All of them were very impressed by the fact that not all the bats living in the area were vampires. Eco-Club could be a very important contact for continued education in the area. The radio program created in Mexico as a part of a collaboration between BCI and the Mexican Bat Conservation Program (PCMM), "Aventuras al Vuelo", could provide very important material to air and probably an example for creation of Paraguayan programs about bats in the local language (Guarani) or bilingual (Guarani-Spanish).

Tres Gigantes

From September 7-12, the workshop continued at Los Tres Gigantes Biological Station located on the Paraguayan bank of the Rio Negro. The work at Tres Gigantes included capturing bats (using ground, triple-high, and harp trap) acoustic monitoring and roost searches. An important activity was to form small groups so participants could practice basic study design, bat survey techniques, data analysis and presentation. The same presentations given in Asuncion by Dr. Merlin Tuttle, Dr. Luis F. Aguirre and Lic. Kathrin Barboza were repeated for all the participants as they were not present in Asuncion because they were traveling to Los Tres Gigantes.

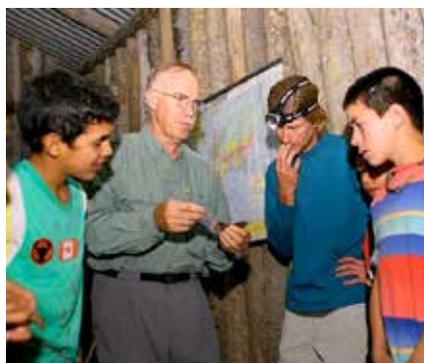


Fig. 6. Dr. Merlin Tuttle introduces the youth of Bahia Negra to bats during a lecture at the EcoClub Pantanal Paraguayo.

Fig. 7. Using triple-high mist nets, harp traps and mist nets to capture bats at Los Tres Gigantes Biological Station, Alto Paraguay.

Preliminary mist netting and trapping

Daytime activities for the first couple of days, in addition to lecture presentations, involved searching the area for suitable capture locations and potential roosts. The area consisted mostly of open habitat with palm tree formations (*Copernicia alba*) and riparian forests. Two major trails were created for wildlife observation: the Jurumi Trail and the Arira'i Trail. Jurumi Trail was located in riparian forest that continued into open palm habitat and the Arira'i Trail was riparian forest that continued into open savanna. The first two nights the instructors and workshop participants worked together to place mist nets and a bat trap in both trails, as site choices were explained. Participants had the opportunity to place mist nets and to remove bats in collaboration with the instructors (Fig. 7).

During the workshop at Tres Gigantes, we experienced a strong cold front from the south, with very low temperatures that lasted for almost the entire time. Nevertheless, after two nights of preliminary mist netting, we were able to register several species of bats that regularly use the forest interior. Those included the White-throated Round-eared Bat (*Lophostoma silvicolum*), and the Great Fruit-eating Bat (*Artibeus lituratus*).

Together with ground-level mist nets, a high mist net ("Triple High") was erected in an open area in order to capture higher-flying bats (up to 8 m). Participants learned to mount, move, and disassemble the Triple High and remove captured bats (Fig. 7). This device was able to capture species of bats that were not found in ground-level mist nets, such as the Yellow bat, the Dwarf dog-faced bat (*Molossops temminckii*) and the Lesser Fish Eating bat (*Noctilio albiventris*).

The Harp Trap was also introduced as an important method for catching small insectivorous bats that often avoid capture in mist nets. This trap was set in small clearings with closed canopy in both riparian forests. Participants learned to set the trap (Fig. 7), which captured several individuals of the Riparian bat and Yellow bat. Even though those bats were sampled in mist nets as well, the Harp Trap caught more individuals, demonstrating its practicality especially for vespertilionids. The trap also caught White-throated round-eared Bats and Great Fruit-eating Bats.



Roost search

During the day, we searched in the surroundings for roosts. We found that the area has a high density of termite nests (mostly in palm formations) that were potential roosts for the White-throated round-eared bats (Fig. 8). Although we could not confirm the use of any particular termite nest by bats, we found several that showed signs of recent occupation. The feces found underneath the termite nests corresponded to the Lesser Fish Eating bats (easily recognizable by the characteristic smell of the bat), and under one particular abandoned termite nest we found the skull of this species. If confirmed this would represent a novel-type of roost for this species. In addition to termite nests, one of the participants found a Great Fruit-eating Bat roosting beneath a dense mat of vines along the Arira'i Trail (Fig. 8).



Fig. 8. Bat roost in termite nest (L) and roost of *Artibeus lituratus* in foliage (R) at Lost Tres Gigantes Biological Station, Alto Paraguay.

Acoustic monitoring

Participants also practiced use of echolocation detectors as a means of documenting bat activity and establishing species presence. This work was done under the direction of Ted Weller and Kathrin Barboza. During the first two nights of the stay at Los Tres Gigantes, participants were able to practice listening for and recording the sounds of free-flying bats during the mist net surveys. Participants later used echolocation recorders as the basis for their individual projects to compare activity levels and species identities between the two trails and Rio Negra using transects

In addition, reference recordings were made from most captured individuals. Captured individuals were released and their echolocation calls recorded as they flew either tethered with thread, with a small light tag glued to their ventrum or simply as they were released from the hand. The recorded calls will help form the basis of a reference call library to which free-flying bats that are not captured can be compared. Once the calls of a particular species are well known it is possible to determine the presence of that species without capture. During the workshop, Kat and Ted were able to compile the first reference libraries available anywhere for *Lasiurus ega* and *Myotis riparius*, the 2 most frequently captured bats in Bahia Negra and Los Tres Gigantes. These libraries will be invaluable for future acoustic surveys in Alto Paraguay and will be distributed to Guyra Paraguay and any others interested in conducting such surveys. In addition, the call signatures from several other species in the area were confirmed by comparison to Kat Barboza's call libraries from Bolivia, Ecuador, and Panama. These species include *Noctilio albiventris* and *Molossops temminckii* (Fig. 9).

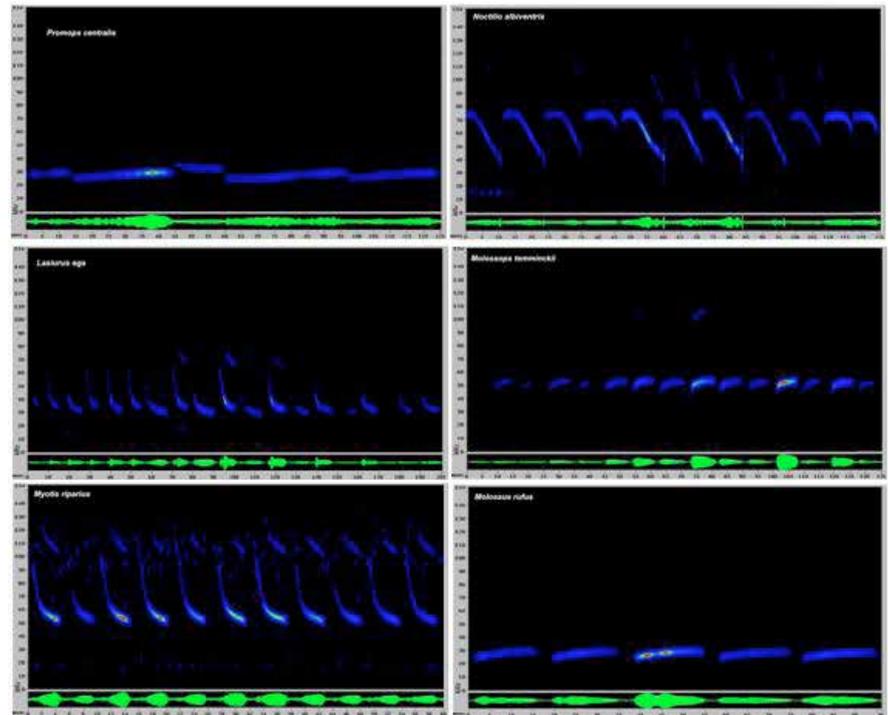


Fig. 9. Echolocation sequence from six bat species recorded at Los Tres Gigantes Biological Station, Alto Paraguay, September 2009.



Fig. 10. Mist netting, identification and acoustic monitoring during participant projects at Los Tres Gigantes Biological Station, Alto Paraguay.

Group Projects

An important activity on the last two working nights was the development of projects by small groups of participants. Instructors gave an introduction on sampling design, including how to formulate a research question that could be addressed and to identify some confounding factors (i.e. full moon, presence of river, weather). The introduction considered also how to analyze bat species assemblages, including: sampling effort (accumulation curves), diversity and evenness (rank-abundance curves) and similarity indexes. We discussed with them some limitations of the projects, mainly the sample size, so it was clear that this was an exercise to practice the techniques learned in previous evenings, handling bats and identifying them using keys but within the context of a mini-project.

After discussing research questions, two groups were formed:

Mist netting group.

They were left alone to set up mist nets in places they considered useful to capture bats in the selected areas, and instructors supervised the procedure. The sampling design included placing mist nets in three different habitats: riparian forest without significant influence of palm trees, riparian forests with significant influence of palm trees and the human settlement area around the field station. After capturing bats they practiced identification using field keys from Argentina (Barquez & Díaz 2009), Bolivia (Aguirre *et al.* 2009), Paraguay (López-González 2005) and Brazil (Gregorin & Taddei 2002) as shown in Figure 10.

Acoustic monitoring group.

As the method of using bat detectors is more complex, they worked more closely with instructors Ted Weller and Kathrin Barboza. The sampling design included monitoring bats acoustically along 100 m transects located in the river, in an open area, and inside a riparian forest. Later, they practiced with the instructors using software to identify bat calls.

After two days of sampling and recording bats, each group wrote a brief report explaining what they had accomplished after being introduced on the basic format of manuscripts. During the last day in Bahía Negra, they presented their report in a Power Point presentation for about 15 minutes per group and 10 minutes of questions.

The format of breaking up in small groups and having them address a simple research question from study design and field methods to analysis of results and presentation (written and oral) was a good chance to workshop dynamics and was positively evaluated by the students. For the first time, participants were responsible for implementing the techniques they had learned to address a question of interest to them. The instructors agreed that this technique is one that should be used by workshops elsewhere when time allows.

Species account

After eight days of bat survey at Bahía Negra and Tres Gigantes, we were able to confirm the presence of 14 species and acoustically detected

the presence of at least 3 others (but could not assign them to species) for a total of at least 17 species of bats (31% of the species in Paraguay; Table 1). By comparison to the book “*Murciélagos del Paraguay*” (Lopez-Gonzalez 2005) our surveys resulted in new records for Alto Paraguay for five (5) species: *Artibeus lituratus*, *Lophostoma silvicolum*, *Myotis riparius*, *Promops centralis* and *Tadarida brasiliensis*. That *M. riparius* would be a new species for Alto Paraguay is somewhat surprising as it appeared to be one of the most abundant species in both Bahía Negra and Los Tres Gigantes. As previously noted, the species identity of *T. brasiliensis* needs to be confirmed from the collected specimen. *Promops centralis* was identified solely on the basis of acoustic records, but sonogram depiction of its echolocation calls is unmistakable.

Table 1 demonstrates the importance of using varied techniques to record bats and improves inventory completeness. Mist netting and acoustic monitoring each detected 10 species, but four species were recorded exclusively by mist netting (*Lophostoma brasiliensis*), and four more exclusively by acoustic monitoring (two species from the genus *Eumops*, *Promops centralis* and a vespertilionid recorded at 40 Khz). Although the harp trap captured only four species, one of them, *Myotis nigricans*, was not detected by standard mist nets. Also, most of the individuals of *Myotis riparius* at Tres Gigantes were captured using the harp trap (8 out of 13), demonstrating the importance of this trap in registering these small bats. The Triple-high mist net was an excellent method for capturing bats in open areas, and in Tres Gigantes was the only way of capturing *Noctilio albiventris* besides recording it. By searching for roosts we were able to find

4 species of bats, and the only vampire bat seen for the entire trip was in a building, an unusual roost choice for this species.

Future directions

Following the completion of the workshop the instructors had time to discuss ideas for further bat work in Paraguay. Our ideas centered on capitalizing on the momentum of the workshop: both among the 10 participants in the field workshop and among the audience members from the lectures in Asuncion. Here we offer several potential avenues of exploration.

Bat Conservation Program for Paraguay

One important direction is to develop a formal bat conservation program for Paraguay. Such a program could eventually have education, conservation and research sub-programs, but could begin by pursuing any of these topics. At least one participant (Nery Chamorro) expressed interest in beginning a bat education program. Perhaps this could be the first step in initiating a more comprehensive program. Luis Aguirre has experience in initiating bat conservation programs in Bolivia and elsewhere throughout South America and has offered to help in Paraguay. He could share materials and convey lessons learned from other countries. Luis has suggested that a successful model for initiating a conservation program is to host a mini-symposium followed by a working group to discuss the needs and directions for a proposed conservation program. The sympo-

Table 1

Family Subfamily Species (Location)	Mist Net	Harp Trap	Triple Height	Acoustic
Noctilionidae				
<i>Noctilio albiventris</i> (BN-TG)	X		X	X
Phyllostomidae				
Phyllostominae				
<i>Lophostoma silvicolum</i> (TG)	X	X		
Stenoderminae				
<i>Artibeus lituratus</i> (TG)	X	X		
<i>Platyrrhinus lineatus</i> (TG)	X			
Desmodontinae				
<i>Desmodus rotundus</i> (BN)				
Vespertilionidae				
<i>Lasiurus ega</i> (BN-TG)	X		X	X
<i>Myotis nigricans</i> (TG)		X		
<i>Myotis riparius</i> (BN-TG)	X	X		X
Vesp. 40Khz (BN-TG)				X
Molossidae				
<i>Eumops</i> 20kHz (BN-TG)				X
<i>Eumops</i> 15kHz (BN-TG)				X
<i>Molossops temminckii</i> (BN-TG)	X		X	X
<i>Molossus rufus</i> (BN-TG)	X		X	X
<i>Molossus currentium</i> (TG)	X			
<i>Molossus molossus</i> (BN)	X			X
<i>Promops centralis</i> (BN-TG)				X
<i>Tadarida brasiliensis</i> (BN)	X			

Species of bats found using various techniques during the workshop. BN: Bahía Negra; TG: Tres Gigantes.

sium would call together all bat workers from the country – and those interested in working on bat conservation – to share what they have been doing and discuss ways to collaborate through a conservation program. A key step in establishing a conservation program is to identify a leader of the group – someone to keep the group organized and moving forward.

Education

A similar theme is to develop a bat education program for Paraguay to convey the ecological benefits of bats to the populace and dispel ideas that all bats are vampires and dispersers of diseases. Ideas focused on educating children through school programs and formalizing a bat education component into the work of Eco-Club Pantanal Paraguayo, which already conducts such work. We discussed production of some basic educational materials (small pamphlet with photographs) that could be distributed during these programs. Both Luis Aguirre and BCI have extensive experience in creating such materials and have offered their assistance. Other ideas include topic-specific workshops such as workshops for government officials on vampire bat control or one that would provide skills training for how to present conservation programs on bats.

Further Training

The workshop was a great success in exposing Paraguayan biologists to the world of bats and the techniques used to inventory, monitor and study them. By the end of the workshop the students had accumulated a wealth of knowledge on taxonomy, habitats, behavior, and conservation needs of bats. They were also comfortable trapping, handling, and identifying bats (the latter under the supervision of instructors). Maintenance of such skills requires frequent repetition and practice. Such skills can best be developed in small groups (2-4 people) working intensively with a skilled bat worker for a period of 1-2 weeks. For instance, if Guyra Paraguay would like to pursue bat inventories at some of its other field stations or properties, it will be necessary to develop a resident bat expert to oversee this work (and supervise assistance). Although there were some excellent students, who learned quickly, none of them are currently capable of conducting comprehensive inventories because of the specialized skills necessary to identify some species of bats – both in the hand (e.g., determining dental characteristics) and acoustically, and to develop a sampling design to cover a research activity. We simply didn't have enough time in the workshop to develop this level of expertise in the participants. However we are confident that such a skill set could be developed with intensive field study as described above. One idea discussed was to develop such skills during the course of a small research project supervised by one of the instructors of this workshop (or others in country, i.e. Dr. Robert Owen).

Artificial Roosts

We discussed the possibility of introducing artificial roosts at Los Tres Gigantes and other locations where bat populations and species diversity might be limited by a lack of roost

structures. We are aware of several potential designs that have been used successfully in tropical areas. One in particular, made from a concrete and sawdust mixture can house hundreds of bats (Kelm 2008). Wooden houses with tin roofs can accommodate hundreds to thousands of insectivorous bats, and their out-flights can become a popular eco tour activity (described in Bat House Builder's Handbook, available from BCI) These can be constructed on-site using local labor and comparison among different types of artificial roost designs could become a topic of research. These could be especially effective and popular in Bahia Negra where so many natural roosts have been destroyed.

Research

As a country with a relatively unexplored bat fauna there an abundance of research topics could be undertaken which would help to understand the behavior, ecological roles, and conservation needs of bats in Paraguay. We developed the following list of potential topics during our visit to only one small (yet biodiversity-rich) portion of the country. Obviously the list would grow with visits to other areas:

- Survey to provide a list of bat diversity and extraordinary bat hotspots covering Paraguay's most important habitat types.
- Compilation of a reference library of acoustic calls to facilitate future surveys
- Survey of Paraguayan caves to determine which, if any, are of special importance to large or endangered bat populations and to characterize any that are.
- Documentation of bat roles in forest regeneration (seed dispersal) and/or pollination, especially for trees/shrubs of economic importance.
- Comparison of artificial roosts to determine most effective vs. economical types and potential use, especially around villages where many natural roosts have been destroyed.

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