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Baseline Surveys of Bridges and Modeling of Occupancy for Bats in California

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Introduction

The importance of bridges as roosts to support populations of bats is well documented in Europe (Shiel, 1999; Smiddy, 1991) and the United States (Adam and Hayes, 2000; Davis and Cockrum, 1963), including use by endangered species, such as the Indiana bat (*Myotis sodalis*—Kiser et al., 2002). Bridges can support day, night, maternity, and migratory roosts (Adam and Hayes, 2000; Lance et al., 2001; Ormsbee et al., in press). Despite their artificial nature, bridges provide thermal stability, offer protection from predators, are close to foraging areas, and afford space for socialization (Altringham, 1996).

In California, 24 species of bat occur, and all are protected by state law. Fifteen species are considered rare, species of special concern, or otherwise regarded as warranting further conservation consideration. Fourteen of these species likely use at least some of the 12,000 bridges that are owned by the California Department of Transportation (Caltrans—Erickson, 2002).

Usually, a minority of bridges in an area actually supports bats (Felts, 2003; Johnson et al., 2002; Trousdale and Beckett, 2002), but determining which ones do is challenging. Few biologists have the expertise to evaluate bridges, and there often are delays in obtaining specialized help, even when funding is available. Consequently, data on occupancy by bats exist for few bridges in California. To determine the feasibility and possible approaches for a statewide assessment of use of bridges by bats, Caltrans initiated a pilot study in 2005 to assess 316 bridges in Ventura County, northwest of Los Angeles. Bridges in this county have a variety of forms and surrounding habitats, including urban, suburban, and rural land.

Methods

In 2005, information concerning bridges was first reviewed in the office by consulting biologists (i.e., Level 1 Assessment—Erickson, 2002). These data were collected from biannual inspection reports that are required by the Federal Highway Administration from departments of transportation in each state. Features of bridges that correlate with use by bats are well known (e.g., Adam and Hayes, 2000; Davis and Cockrum, 1963; Ormsbee, in press), and the biologists classified each bridge according to its probability of occupancy by bats, generally following Erickson (2002). Bridges with high probability for occupancy were structures with two or more of these characteristics: built before 1950, located in a rural area, constructed over a waterway, or possessing girder construction (including concrete, timber, and steel materials). Bridges with girders also usually contained expansion or hinge joints—narrow grooves perpendicular to the roadway that allowed daily thermal expansion and contraction of the bridge. Bridges with intermediate probability had at least one high-probability characteristic or had one or more of these joints. Bridges labeled as low probability were built after 2000, had concrete-slab construction, or were bridges with slab/enclosed-box construction without joints.

For Level 2 Assessments, an experienced biologist attempted to survey all high- and intermediate-scoring bridges in the field, during the day, between 23 July and 3 October 2005. In addition, 25% of bridges that were labeled as low probability at Level 1 were randomly surveyed in the field to validate the model. Visual observations were made with the assistance of binoculars and a spotlight, and infrared video cameras mounted on extension poles sometimes were used to help determine occupancy. Positive indicators of use by bats included live or dead individuals, urine stains, guano, vocalizations audible to humans, and distinctive odors.

If bats were detected during Level 2 Assessments, Level 3 fieldwork (ultrasonic and visual surveys) was conducted at night between 13 September and 3 October 2005, to identify species, estimate abundance, and determine how the roost was used. These surveys were done by biologists experienced with such field techniques. One to three acoustic-detection units (Anabat, Titley Electronics, New Ballina, Australia) were used at each bridge, starting prior to sunset and continuing at least to 2200 h.

Results and Discussion

During Level 1 Assessment, 63 bridges (20%) were rated as high probability for bat occupancy; 49 (16%) were scored as intermediate, and the remaining 204 (65%) were graded low. Although 51 low-ranked bridges were selected for field assessment (Level 2), seven of these bridges could not be surveyed in the field because of problems with access or safety. Nevertheless, of 150 bridges surveyed in the field (Level 2 and 3 combined), 30 (20%) had evidence of bats. Nine of those bridges were day-roosting sites for bats (primarily *Tadarida brasiliensis*, *Antrozous pallidus*, and *Myotis californicus*), whereas 20 bridges were used as night roosts; in one case, the bridge acted as a migratory roost. At least 30 occupied structures among the 316 bridges in the county yielded a minimum occupancy rate of 9.5%.

All bridges with evidence of bats in the field had been ranked as high probability during the Level 1 assessment, except for one intermediate-ranked bridge and four low-ranked bridges. Forty-three of the 47 low-ranked bridges surveyed in the field had no indication of occupancy by bats; thus, the Level 1 assessment was 91.5% correct. For intermediate-ranked bridges, 25 of 26 bridges did not support bats (98% unoccupied). At the five bridges that sheltered bats even though the bridges initially were ranked as low or intermediate, few individuals occurred, suggesting that roosting conditions or surrounding habitat was suboptimal. Of the 58 bridges ranked high in the office and surveyed in the field, 25 (43%) were actually in use. Although not quantified, variables that appeared associated with use of bridges by bats were suitable adjacent foraging habitat (e.g., riparian forest), rural setting, negligible daytime lighting, limited human activity, a bridge crossing a waterway, and actual presence of water.

Minor adjustment of the initial screening criteria would have improved classification results. For example, presence of open (non-caulked) expansion joints was integral to occupancy, not just the presence of a narrow crevice that is noted in inspection reports. The addition of other characteristics in the Level 1 screening may have allowed correct classification of other low-ranked bridges.

For example, our preliminary analysis suggests that high bridges may be used because they allow bats to be farther from people and that wider bridges may have more potential habitat (roosting sites). Consideration of the type of adjacent habitat also may have improved the results.

Although the ranking criteria were tested in Southern California, we hypothesize that the parameters are valid in other locations with the same suite of species. This hypothesis assumes that the ecological roosting requirements for these widely distributed species are consistent. Furthermore, time of year must also be considered when conducting single surveys, especially for roosts that may be migratory and/or small. A number of our field surveys, for example, took place in September and October, and we may have missed summer residents.

The risk of a false negative finding with a Level 1 screening must be considered, especially when listed or otherwise rare species are involved. A biologist may choose to change the criteria to be more conservative, thus including more structures in Level 2 surveys. However, this choice would result in monetary expense, time, and other logistic tradeoffs.

In summary, our data demonstrate that using an initial in-office screening, followed by focused surveys in the field by a qualified biologist, is a cost effective (ca. US$480/bridge) approach to obtain data on bat use of many bridges. By considering specific roosting needs of bat species occurring in an area, biologists or highway departments could apply this method anywhere to establish a baseline, and the procedure would be especially valuable when personnel and/or funding are limited. Periodic follow-up surveys involving less time and funding at identified roosts could then be used to monitor status, detect trends, and implement focused, beneficial management actions on behalf of bats.

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Noteworthy Records of *Eptesicus brasiliensis* (Vespertilionidae) from Oaxaca, Mexico

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The Brazilian brown bat, *Eptesicus brasiliensis*, is distributed from southern Mexico to northern Argentina, Paraguay, and Uruguay, as well as on the islands of Trinidad and Tobago (Simmons, 2005). *E. brasiliensis* inhabits lowlands up to an altitude of 3,000 m but usually occurs at sites above 1,000 m (Reid, 1997). Previously reported records of *E. brasiliensis* in Mexico are from the states of Veracruz (Baker and Patton, 1967) and Chiapas (Davis, 1966).

On 14 July 2004, during a field trip to the Municipio of San Miguel Chimalapa in southeastern Oaxaca, Mexico, we caught an adult female *E. brasiliensis* in a mist net that was set over a path near a riparian corridor. The netting site was close to the boundary with the state of Chiapas, 5.9 km NW of Benito Juárez (16° 44’ 20”N, 94° 11’ 45”W) at an elevation of 1,700 m. The local vegetation is part of an ecotone between cloud and tropical perennifolious forest.

Total length of the specimen was 99.6 mm; forearm length, 43.5 mm; tail length, 43 mm; length of hind foot, 8 mm; height of ear, 14 mm; and weight, 12 g. Dorsal pelage was brown-blackish in color, with a length of 10 mm, a length that is characteristic of this species (>8 mm—Hall, 1981). Greatest length of the skull was 16.29 mm; least interorbital breadth, 4.01 mm; breadth of braincase, 7.79 mm; length of maxillary tooth, 6.23 mm; zygomatic breadth, 10.72 mm; mandibular length, 12.56 mm; and length of mandibular tooth row, 6.6 mm. The specimen was prepared as a skin and skull and is currently in the personal collection of AS-M.

After capture of this individual, we learned of two previously unreported specimens of *E. brasiliensis* from Oaxaca that were held at the California Academy of Sciences (CAS MAM 14084 and 15004). These bats, a male and a female, were collected at La Cima (16°13' 6.1464"N, 96°58' 6.2941"W), near San Pedro Juchatengo, and were received by the museum on 11 March and 15 April 1968, respectively. The specimens from CAS originally were identified as the Argentinian brown bat, *E. furinalis*, and later re-identified as *E. brasiliensis* by V. van Cakenberghe in 1996.

The nearest published record of *E. brasiliensis* in Mexico is from Finca El Paraiso (16°51' 1"N, 91°59' 54"W), in Chiapas (Davis, 1966). San Pedro Juchatengo, the collecting locality for the specimens from CAS, is located ca. 534 km from Finca El Paraiso, and San Miguel Chimalapa, where we mist-netted an *E. brasiliensis*, is located about midway between these two sites. Thus, these three specimens extend the range of *E. brasiliensis* by over 500 km and increase the total number of species of bat reported in Oaxaca to 84.

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Photo courtesy of Rodrigo Medellín

Bernardo Villa Ramírez: 1911–2006

Rodrigo A. Medellín

Bernardo Villa Ramírez (known to many as Bernardo, Doc Villa, El Doctor Villa, or Batman) was born in the mountains of the state of Guerrero, in southern Mexico, on 11 May 1911. Guerrero was one of the poorest states in Mexico, and its people were mostly Native Americans of Aztec descent. Bernardo grew up in the midst of a Native American family and did not begin learning Spanish until age 12.

He eventually left his home town of Teloloapan for Mexico City in an ambitious, restless pursuit of academic improvement. He first studied to become a rural elementary school teacher, and because he always was committed to serving his community, he went back to Teloloapan to teach in the tiny school that can still be seen there. In the 1930s, nature's magnet attracted Bernardo to become a biologist, one of the first trained biologists of Mexico. After obtaining a master's degree from his beloved UNAM, the National University of Mexico, his determination pushed him to take his three children and wife to the University of Kansas, where he enrolled in a master's program under the direction of the legendary E. Raymond Hall. During this period, he successfully faced yet another challenge: learning English, his third language after his native Nahuatl and Spanish.

By 1947, Bernardo, with his master's degree, had become a faculty member in the

Instituto de Biología of UNAM, his home institution for many decades. In the same year he initiated the collection of mammals at the Instituto, and today, that collection is the largest in Mexico and considered the official national collection of mammals by the federal government. Bernardo ultimately pursued a doctoral degree at UNAM, which he received in 1966 after completing his dissertation *The Bats of Mexico*. His dissertation was later published as a book that became the standard reference for bats in Mexico and greatly stimulated the study of these flying mammals by natives of Mexico and international researchers.

Bernardo Villa directed over 40 theses and dissertations and taught scores of courses at UNAM and other institutions. His academic children, grandchildren, and great-grandchildren are today in key positions in academic institutions across Mexico and in other countries. He published over 100 papers and established collaborations with dozens of researchers from many countries. The National System of Researchers made him an emeritus researcher over 10 years ago. He was a member of the American Society of Mammalogists for five decades, and that society awarded him an honorary membership in 1999. He became an emeritus professor at UNAM, and even as he aged into his 90s, he continued to go to his beloved Instituto once or twice a week to advise students and discuss projects. He strongly supported the idea of a few young students, back in the early 1980s, to form the Mexican Society of Mammalogists, for which he served as external advisor and honorary president. Today the Mexican Society of Mammalogists and the North American Symposium on Bat Research have their respective Bernardo Villa Awards, appropriately given to the brightest student in each society. His influential work truly shaped today's mammalogy in Mexico, and most, if not all, people studying bats in Mexico can trace their origin to Bernardo.

His joviality and astonishing memory are the material of legends. He was always ready to discuss questions about mammals, which invariably evoked stories from his youth. On one occasion, he was working in a cave in his native state of Guerrero when his then young children, only 8- and 10-years old, started calling to their dad, who was deep in the dusty cave catching bats. When Bernardo surfaced, he was met by a shotgun pointed at him and others that were aimed at his children. Bernardo's face was covered by a handkerchief and a headlamp, and the faces of the *bandidos* also were covered by handkerchiefs and sombreros. Bernardo, in his usual affable way and with the cold blood that was brought up under any life-threatening circumstance, started removing his equipment. When his face was visible, the chief of the *bandidos* said: "Maestro Villa! What were you doing in that hole? Why didn't you tell us that you were around here?" It turned out that the chief of the *bandidos* had been one of Bernardo's elementary school students in Teloloapan, and after that encounter, the *bandido* became one of Bernardo's major guides during visits to his native Guerrero. Stories like this are plentiful whenever you mention the name Bernardo Villa.

Bernardo's legacy was not limited to academia. He took a decisive step when, in the 1960s, he joined the federal government as head of the Wildlife Department; he maintained that position for several years and continued advising the government for the rest of his life. He touched thousands of young biologists through his cordial, welcoming personality and his exceptionally enthusiastic and open style. My own destiny was sealed when Dr. Villa, in one of the abundant examples of his generosity, called my home after I had appeared on television as a 12-year-old mammal enthusiast and invited me to join him and his team in the field. Bernardo counted many friends in dozens of countries, and he left a heritage that spans decades, thousands of people, and millions of square kilometers. His footprints were so positive and constructive that he was appreciated and welcomed by everyone—farmers, Indians, scholars, Mexicans, and citizens of other countries. His life was a true example of what can be achieved through determination, energy, and intelligence, coupled with warmth, hospitality, and friendship.

In the Field with Bernardo Villa-R.

G. Roy Horst

Those of us fortunate enough to have known Bernardo Villa are acutely aware that there was far more to him than Rodrigo Medellin's account reveals to us. What was Bernardo—that fellow at the other end of a bat net or just ahead of you in a dark and muddy cave—really like to work with? He was a genuine delight, invariably in a jovial and pleasant mood, intensely interested in what was going on, and always interested in those around him. He had a wonderful sense of humor and loved a good joke, even though sometimes much was lost in translation. He was a kind and enthusiastic coworker and always a welcome companion.

Bernardo especially enjoyed being in the field, which often meant being in a cave, an old building, or the jungle. Fieldwork to him was always an adventure. All of his friends and associates especially remember the pleasant companion he was on those long drives to some distant site. It was on such trips and under often strange or unusual circumstances that one really came to know him. His role on many field trips and excursions was invariably to serve as leader, as translator in the sometimes delicate discussions with local authorities, and as the ultimate expert at identifying every bat we ever caught. He also served as a guide to remote places, but surprisingly he was often as lost as his visiting traveling companions. The following are just a few of my recollections about interesting events that occurred when Bernardo and the late Bill Wimsatt traveled throughout Mexico in search of various species of bats. In these adventures I was fortunate to be a fellow traveler, even if at first only a mere graduate assistant.

Especially amusing was my first experience with Bernardo and Bill, which happened during my first field trip ever into tropical bat country. Bernardo had long been interested in a small colony of *Balantiopteryx io* near Orizaba. On several previous occasions, he had attempted to capture a few specimens, without success. He described the site to Bill and me and we decided that we would make an attempt to obtain a few specimens for their collections. This colony roosted just inside the opening in the anterior part of a small amphitheater-like cave, which was at the base of a vertical cliff and opened onto a pasture. Any attempt to approach the entrance of the cave was almost immediately followed by the bats flying out and escaping—hence Bernardo's previous lack of success. This problem of approach became the object of some serious planning by my two great leaders while I observed with silent admiration, ignorant neophyte that I was. The plan was that we would take a ten-meter bat net and attach it to two very fancy, custom-made telescoping aluminum poles, which Bill had commissioned to be made at considerable expense. The plan was that Bill would take one end and Bernardo would take the trailing end of the outstretched net, with me standing by. We would charge along, hugging the side of the cliff, and move quickly across the cave entrance, blocking it with the outstretched net. Once the net was in place, I would quickly duck inside and capture as many bats as possible as they became ensnared in the net that would be securely blocking the entrance to the cave.

We assembled the apparatus off to one side of the cave so as not to alert the bats, and to make certain of success we viewed the cave entrance and its surrounding terrain from a point far back from the opening. We could not actually see into the cave, but rather could only glimpse its opening from a side angle. Bernardo went over the plan again and we were ready to execute a great coup on the *Balantiopteryx*.

The signal was given and we charged—Bill, as always, in the lead, Bernardo following, me standing by. Almost in the same instant, Bill suddenly developed an astounded look on his face, the likes of which I had not seen before (nor since), and Bernardo looked like he desperately wanted to be somewhere else. It happened that a Brahma bull had been resting in the entrance of the cave. At our sudden appearance, he immediately charged out—roaring—and fled downhill away from the scene. And what a scene it was—an angry bellowing bull with a bat net draped across his horns. Wimsatt's fancy poles were bouncing on the ground, rebounding to strike the bull over and over until the bull disappeared into a woods a few hundred meters away. There was little doubt in our minds that the bull was awaiting his chance to turn on his tormentors as they came to rescue their net and poles. A short (very short) discussion ensued as to which one of us would go down into that woods and retrieve our equipment. There were no volunteers; in such cases graduate students were invariably expected to volunteer. I pathetically mentioned something about my wife and baby boy back at home and Bill commented on how much those fancy poles had cost him. Bernardo settled the issue by offering to pay Bill whatever sum new poles would cost. Any thoughts of recovery were ended then and there as by now we could hear the bull returning and we quickly fled the scene. Bernardo never did get those *Balantiopteryx*, and we wondered ever after what the farmer thought when he recovered his netted bull.

In 1970 on the occasion of the First North American Symposium on Bat Research in Tucson, Bernardo and Mrs. Villa decided to accept our invitation and spend a few extra days as our houseguests. They expressed a desire to visit the ancient historic Indian Mission of San Xavier del Baq just south of Tucson, so we arranged an afternoon's visit to this beautiful old mission. One of the delightful customs of the Indian women in the congregation is that each Christmas they create lovely native costumes to clothe the statues of the various saints that decorate the chapel of the mission. One of the mission priests served as our guide to the history and services of the mission, much to the delight of all of us and especially to Bernardo and Clemencia, who were devout Catholics.

At this time Mrs. Villa was not enjoying the best of health and as we finished our tour, the Villas asked the priest if he would offer a prayer on her behalf, which he graciously did. As they knelt in front of the statue of The Virgin Mary (the statue stood on a pedestal that is just at eye level when one is kneeling), Bernardo noticed some bat droppings scattered at the feet of the statue. After the prayer was completed, Bernardo very politely and discreetly called the priest's attention to the droppings and mentioned that there must be bats hiding in the robes of the statue, expressing concern that they would soil the beautiful clothes so lovingly crafted by the ladies of the congregation. He informed the priest that he was a bat biologist and offered to remove them. The priest expressed embarrassment that a man might presume to reach under the skirts of so sacred a statue but allowed that Clemencia might wish to do it, and she did, retrieving two *Myotis thysanodes*.

We took the bats back to our home and Bernardo prepared museum specimens of them. The label Bernardo prepared read very straightforwardly: *"Taken from under the skirts of the statue of the Holy Mother in the Chapel of San Xavier del Baq, 14 km south of Tucson, Arizona."* He commented that this might be one of the more unique museum labels for any bat ever, but on second thought feared it might seem a bit irreverent and produced a more conventional tag for those specimens. If only he had only left the original!

Bernardo was always a resourceful field worker and was especially adept at taking advantage of any opportunity or methodology to collect specimens of interest. On one of our field trips to the area south of Vera Cruz near Tlacotalpan, Bernardo kept suggesting that in addition to collecting *Molossus ater* and *Desmodus rotundus*, we should also try to capture a few *Noctilio leporinus*, common in that area. Both Bill and I were intrigued by the idea so the hunt was on.

The terrain in that area was very flat and swampy and nearly every road was bounded on both sides by small canals usually less than three or four meters wide and rarely more than one-half meter deep. These canals were teeming with aquatic life including many small fish. Bernardo assured us that these were favorite hunting grounds for *Noctilio*. He felt that surely we should be able to catch a few and suggested how we could go about this endeavor. One method that Bernardo described, but admitted he had never tried, was to fasten a very thin wire or monofilament line across the canal just a few millimeters beneath the water's surface. The idea was that the bats would be trolling along the surface, catch the invisible wire with those huge forward-facing feet, and their normal gaffing reflex would then dump them unexpectedly into the water. In their suddenly confused state we should be able to catch them by quickly wading in after them. Bill was skeptical (after all he hadn't thought of it himself) and said rather loftily that rather than make a fool of himself wading or falling into a drainage ditch, he would go downstream a few hundred meters, set up a conventional net, and show us how it should be done.

Bernardo and I carefully arranged our wire, sat behind a thick clump of bushes on the bank, and tossed small pieces of twigs into the water just ahead of the wire to simulate fish splashing and feeding on the surface (I thought of that part). How could we fail? Presently we heard the smooth swishing sound of a trolling *Noctilio* and after a series of misses one finally hit our wire. Just as Bernardo had predicted, the bat ended up in the water. Bernardo immediately jumped into the canal and waded after the swimming bat. But just as he reached to catch it, there was a splash and the bat was gone—caught in the jaws of a caiman about a meter in length. Bernardo immediately erupted from the water and walked on its surface the two or three meters to the bank. He used a few choice words in Spanish, which I thought best not to remember. Bill came along a few minutes later to see "what we had caught with all that splashing around." After he had a good laugh at our expense, he handed us two *Noctilio* that he had caught in his net. He never let us forget that incident! It made for many a good laugh later and Bernardo loved telling about it—except the caiman became larger with time!

There were many other equally fascinating events and adventures while in the field with this great mentor and companion. Fortunately at the time I was keeping a simple journal of my field trips and managed to scribble done a few lines on some of those occasions. I regret that I did not have a camera to record at least some of those events. I also regret that none of us will ever have such wonderful experiences with him again. The next time you meet some of your colleagues whom you suspect may have traveled or worked with Dr. Villa, please ask them about their experiences with him; they will enjoy telling you of their memories, and Bernardo's legacy will be preserved.

Photo courtesy of Rodrigo Medellín

Selected Publications by Bernardo Villa-R.

Margaret A. Griffiths

The following bibliography of publications by Bernardo Villa-R. was compiled from a variety of sources by the Editor because a complete list was unavailable. Omissions, incomplete citations, and misspellings, especially that of Spanish words and accent marks, in the following list are inadvertent, and she apologizes in advance for any errors.

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ADDENDUM

36th Annual North American Symposium on Bat Research Abstracts

The abstract below was presented at the 36th Annual NASBR meeting and was inadvertently left out of the 36th meeting abstract book and thus also not published in *Bat Research News*, Volume 47: Number 4 (Winter, 2007). Mary Kay Clark and I both apologize for this oversight.

Myotis vivesi, the Bird-like Bat

Dave S. Johnston, Luis Gerardo Herrera Montalvo, and Jose Juan Flores Martinez, San Jose State University/H. T. Harvey & Associates, San Jose, CA; Universidad Nacional Autónoma de México, D. F., México; Ciudad Universitaria, D. F., México

Previous investigations demonstrated that various species of bats [e.g., *Tadarida brasiliensis* (Molossidae), *Noctilio leporinus* (Noctilionidae), and *Antrozous pallidus* (Vespertilionidae)] have different swimming styles and speeds. We used a portable aquarium and infrared camcorder on Partida Island in the Sea of Cortez to determine swimming style, speed, and the position of the body during bouts of swimming of 20 *Myotis vivesi*. We also measured and determined wing and uropatagium ratios of 20 individuals, and the density of fur on dorsal and ventral pelages of two specimens. During trials in the aquarium, the Mexican fishing bat did not swim significantly faster or in a different style than *Myotis yumanensis* or *M. californicus* in similar trials. However, *M. vivesi* spent a greater amount of time (more times and for longer periods) floating on the water than other species of bats in similar trials. Counter-shading and uropatagium shape may play a role in the adaptive morphology of this species and its life history as a piscivore.

RECENT LITERATURE

Authors are requested to send reprints or PDF files of their papers to the Editor for Recent Literature (Karry Kazial, Dept. of Biology, SUNY Fredonia, Fredonia, NY 14063, U.S.A., email: karry.kazial@fredonia.edu) for inclusion in this section. If reprints are scarce and .pdf files unavailable, please send a complete citation (including complete name of journal and corresponding author mailing address) by email. Thanks to Steve Burnett for BioBase reference software. The Recent Literature section is based on several bibliographic sources and for obvious reasons can never be up-to-date. Any error or omission is inadvertent. Voluntary contributions for this section, especially from researchers outside the United States, are most welcome.

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BOOK REVIEW

A Field Guide to Mammals of North America North of Mexico. 4th Edition. Fiona A. Reid. Houghton Miflin Company, New York.
xx + 579 pp., 2006. ($20.00 United States, $26.95 Canada)

This book, listed by its publisher as being the Fourth Edition of the Peterson Series *Field Guide to Mammals*, might lead some potential purchasers to conclude that it is simply an updated, slightly revised version of the classic Burt and Grossenheider field book on mammals. Nothing could be further from the truth. Author Fiona Reid has followed the traditional format of the Peterson Field Guide series (more or less), but she has crafted a superb new set of plates (66 plates of whole mammals, 14 of mammalian skulls), and she has extensively rewritten the species accounts of every terrestrial, fossorial, volant, and aquatic species of mammal found in and around the North American continent, north of Mexico. Each species account begins with the salient measurements and external characters that help to positively identify the species in question. A section on "Similar Species" follows, which helps the reader differentiate the species in question from potentially confusing species. There is a brief written summary of "Sounds" produced (if any), "Habits," "Habitat," "Range," and conservational "Status" (at the state/province, federal, or international level, as appropriate). Approximately 400 well-done range maps provide accurate distributional data for each species at the national, state, or county (parish) level.

Fifty species of bats are covered in this book, including a few species that barely qualify for inclusion in the "north of Mexico" category (e.g., *Mormoops megalophylla*, *Choeronycteris mexicana*, *Leptonycteris nivalis*, *L. yerbabuenae*, and *Molussus molussus*) and four species that are clearly accidental strays into the southwestern states or the Florida Keys (*Phyllonycteris poeyi*, *Erophylla sezekorni*, *Artibeus jamaicensis*, and *Diphylla ecaudata*). It is probably a good thing for Mammalogy and for mammalogists of the future that Reid includes these species. I am mindful of one of the late Karl F. Koopman's favorite sayings; that he was "all in favor of global warming, as it allows for considerable range extensions of some of my favorite species." It seems likely that as the climate changes, more and more people are likely to encounter leaf-chinned bats, nectarivorous and frugivorous leaf-nosed bats, and perhaps the occasional vampire bat in regions north of Mexico and the Caribbean. If so, they will be well prepared to identify them by this volume.

As in all of the Peterson Field Guides, the great strength of the book is in its illustrations. There are, first of all, numerous color photographs of many species, showing an individual in a naturalistic setting. Eleven of these photographs are of bats, mostly taken by Scott Altenbach or Michael Patrikeev (the latter better known perhaps for his photographs of birds). Not every species of mammal is thus illustrated, but this does not mar the usefulness of the volume, as nearly every species has a magnificent plate created by Fiona Reid. Bats are grouped onto six plates: leaf-chinned and leaf-nosed bats; eastern vesper bats; western vesper bats; tree bats; long-eared vesper bats; and free-tailed bats. For the novice, the eastern and western vesper bats and perhaps some of the free-tailed species will be the most difficult to differentiate. I am very pleased to note that Reid has done everything possible to make this task easier, including providing written explanations as well as pen and ink drawings of a tragus, wing attachments, and what a "keeled" calcar looks like.

I belong to a generation of mammalogists for whom the Burt and Grossenheider *Field*

Guide was an essential text for learning mammalogy both in the lab and in the field. The second edition of this classic volume—released in 1964—was the edition I consulted as an undergraduate, but it was the third edition (1976) that became my inseparable companion on countless forays into the field to study mammals. I am pleased to note that this superb new edition continues to be just as easy to use as previous editions. It is ruggedly bound, with a heavy cover and pages that will withstand arduous field conditions. At 579 pages, it is nearly twice the length of the previous edition (289 pp.), but it will still slide easily into a backpack. I can find no major faults with the book, but do wish that it would be easier to locate the different orders of mammals. Understandably (and quite sensibly), the author follows the latest thinking in how the mammalian orders are related to one another in her arrangement of the orders in this volume (see p. xix for the phylogenetic tree she follows). However, although I am quite aware that bats are now thought to be laurasiatherians rather than archontans, I still look for them toward the front of this field guide rather than more than half way toward the end, grouped as they now are with Carnivora, Artiodactyla, and Cetacea. Future generations of mammalogists will not find this grouping in the least bit peculiar, I am sure, but this cranky old mammalogist will need to make considerable use of this new edition until—through much use—it naturally falls open to the text and plates of his favorite group of mammals!

This book is a gem. It is well worth its very modest price. I recommend it most highly to chiropterologists and to anyone else interested in the mammals of North America.

Thomas A. Griffiths, Department of Biology, Illinois Wesleyan University, Bloomington, IL 61702-2900. E-mail: tgriff@iwu.edu

NEWS

Congratulations to Tim Carter!

Timothy C. Carter received the 2006 Community Partner of the Year from the Wildlife Habitat Council (WHC) for “contributions to wildlife habitat conservation and environmental education at the Unimin Corporation’s Tamms/Elco Plant” in southern Illinois.

FUTURE MEETINGS and EVENTS

April 11–14, 2007
The Arizona Game and Fish Department will host the Biennial Meeting of the Western Bat Working Group at the Hilton Tucson East in Tucson, Arizona, 11–14 April 2007. Information about the meeting, including registration and field trips, is available at the Western Bat Working Group website (**http://www.wbwg.org**).

April 12–14, 2007
The Royal Zoological Society of New South Wales (RZS) and the Australasian Bat Society (ABS) will hold a joint 3-day symposium on bats at the Australian Museum, in Sydney, 12–14 April 2007. Information about the symposium is posted on the ABS (**http://abs.ausbats.org.au/**) and RZS (**http://www.rzsnsw.org.au**) websites, or you may contact the RZS office (**office@rzsnsw.org.au**) or Peggy Eby (**peby@ozemail.com.au**) if you have questions.

May 7–10, 2007
The First International South-East Asian Bat Conference will be held at the Club Andaman Beach Resort Hotel, in Patong, Phuket, Thailand, 7–10 May 2007. Information about the conference is available at **http://www.sc.psu.ac.th/bats/**.

July 29–August 2, 2007
The Cherokee National Forest will host the annual SBDN bat blitz near Roan Mountain/Johnson City, in the Southern Blue Ridge Mountains of northeastern Tennessee. Contact Laura Lewis [**lauralewis@fs.fed.us** or telephone (423) 476-9752] or see **http://www.sbdn.org** for information.

August 19–23, 2007
The 14th International Bat Conference and the 37th Annual NASBR will be held in Mérida, Yucatan, Mexico, 19–23 August 2007. For more information, please check the website at: **http://batconference.confhost.net/**.

August 2008
XIth European Bat Research Symposium will be held in Cluj-Napoca, Romania. For more information, please contact: **farkas@xnet.ro**

August 2011
XIIth European Bat Research Symposium will be held in Lithuania.

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Front Cover Illustration

Ghost-faced bat, *Mormoops megalophylla*, by Fiona A. Reid. This leaf-chinned bat occurs in southern Texas. It has rounded ears and a very peculiar face with flaps of skin on the chin. At rest its tail sticks out of the tail membrane. From: A Field Guide to the Mammals of North America north of Mexico, by Fiona A. Reid. 2006. Houghton Mifflin Co., Boston. Illustrations copyright Fiona A. Reid 2007 (reproduced with permission from the artist).

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Bat Research News is published four times each year, consisting of one volume of four issues. *Bat Research News* publishes short feature articles and general interest notes that are reviewed by at least two scholars in that field. *Bat Research News* also includes abstracts of presentations at bat conferences around the world, letters to the editors, news submitted by our readers, notices and requests, and announcements of future bat conferences worldwide. In addition, *Bat Research News* provides a listing of recent bat-related articles that were published in English. *Bat Research News* is abstracted in several databases (e.g., BIOSIS).

Communications concerning feature articles and "Letters to the Editor" should be addressed to Al Kurta, conservation items to Pat Morton, and all other correspondence including recent literature items to Margaret Griffiths. (Contact information is listed above.)

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From the Editor

Dear Subscribers,

I hope this issue finds you doing well. There are several changes here at *Bat Research News* that I want to share with you.

First, I am sad to report that Karry Kazial has resigned as Editor for Recent Literature. Life with the new baby, Violet, in addition to Karry's continuing commitment to teaching and scholarship, has severely limited her time, and she felt it was in the best interest of all concerned that she step down as Editor. I thank Karry for her service over the past few years, and although all of us at *BRN* are sad to see her step down, we wish her the very, very best and plan to see her at annual NASBR meetings.

In the interim, I am assuming Karry's responsibilities as Editor of Recent Literature and ask that you please send papers and citations directly to me for inclusion in the Recent Lit section of all future issues. And this brings me to the next major change.

Bat Research News is moving to Lycoming College in Williamsport, Pennsylvania! After 26 years at Illinois Wesleyan University, Tom has accepted the position of Provost and Dean of Lycoming College. In fact we should be in Williamsport, Pennsylvania by the time you receive this issue. Therefore, please note the new contact information (listed on the inside front cover of this issue and the Web site) for *Bat Research News* and myself. The new telephone and fax numbers will be posted on the *BRN* Web site as soon as they are available, and will, of course, be included in the Fall issue. I also ask for your patience during this transition—it may take me a bit longer to respond to your messages and requests, especially those that are forwarded from Illinois Wesleyan University. Please know your messages and requests are very important to me, but things can easily be overlooked during this time of transition. Therefore, if I do not respond to your messages within a reasonable period of time, please do contact me again using the updated information posted on the *BRN* website.

Best wishes to you for a productive and enjoyable summer!

Cheers,
Margaret

Daylight Foraging by Natterer's Bat (*Myotis nattereri*) in Northern Poland

Mateusz Ciechanowski and Urszula Anikowska

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On 3 June 2004 at 1930 h (1 h 27 min before sunset), we observed the flight of a small bat in Wejherowo (54°36'N, 18°13'E), in the coastal region of Poland near the Baltic Sea. The bat was flying slowly and in a maneuverable manner, circling at a height of 0.5–4.0 m above the Reda River, which was flowing into an elm-alder forest from adjacent pastures. The sky was cloudless, and the sun was shining brightly. The bat was preying on swarming mayflies (*Ephemera danica*) that were captured in flight and later consumed while the bat roosted ca. 1 m above the ground on the trunks of black alders (*Alnus glutinosa*) that grew on the river bank.

Long, curved ears that were light pink in color, along with a brownish back and white belly, allowed us to identify unambiguously the species as Natterer's bat (*Myotis nattereri*). We also observed a bat, probably the same individual, foraging at this site at 2030–2050 h, although it was flying slightly higher at 5–7 m. The echolocation calls of this bat, heard through a heterodyne ultrasonic detector (Pettersson D-100), confirmed the bat's generic identity; these sounds consisted of dry clicks, with a regular rhythm, fast repetition rate, frequency range of 30–60 kHz, and peak frequency of 40–50 kHz. Seven minutes before sunset, which occurred at 2057 h, this bat perched on the branch of a dying common oak (*Quercus robur*) and hid under loose bark. During the next 0.5 h, ambient temperature decreased from 12.0 to 6.6°C, and the swarming of mayflies and activity of other insects ceased.

Daylight flights of vespertilionid bats are not uncommon. However, such observations are made mostly by amateurs, so species identification is usually lacking (Speakman, 1990). Most European bats that have been identified while flying in daylight are aerial-hawkers, especially open-air flyers, such as the common noctule (*Nyctalus noctula*). The common noctule is the species that is most frequently reported as flying in daylight (e.g., Gubańska, 2003; Krzanowski, 1958; Urban and Zieja, 2003), even though evening emergence typically occurs a few minutes after sunset (Jones and Rydell, 1994). Natterer's bat, in contrast, captures prey close to vegetation (Siemers and Schnitzler, 2000) or by gleaning (Swift and Racey, 2002), and this bat usually emerges from its day roost after dark, typically ca. 75 min after sunset, as do most gleaners and water-surface foragers (Jones and Rydell, 1994). No daylight flights of *M. nattereri* have been reported previously (Topal, 2001). The atypical behavior that we observed may be attributable to low availability of food during the usual nocturnal foraging period, due to low ambient temperatures, combined with the occurrence of abundant prey (mayflies) during the day, even though mayflies are uncommon in most dietary studies of Natterer's bat (Siemers and Swift, 2006; Vaughan, 1997). A similar phenomenon was observed in common noctules that foraged at noon in November, when air temperature exceeded 10°C (Urban and Zieja, 2003).

We thank P. Buczyński for identifying the mayflies.

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Noteworthy Records of *Eptesicus chiriquinus* and *Eptesicus andinus* (Vespertilionidae) from Bolivia

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Currently, only two species of *Eptesicus* are recognized as occurring in Bolivia, *E. furinalis* and *E. andinus* (Aguirre et al., 2003; Salazar-Bravo et al., 2003). Simmons (2005), however, considered the existence of *E. andinus* to be provisional, pending re-examination of known specimens in light of revised diagnoses of *E. andinus* and *E. chiriquinus* (Simmons and Voss, 1998). Herein, I report the first records of *E. chiriquinus* from Bolivia and validate the presence of *E. andinus* with one specimen collected and several captured individuals. Specimens were prepared as skins and skulls and are currently in the mammal collection of the Museo de Historia Natural Alcide d'Orbigny, Cochabamba, Bolivia (MHNC-M).

On 14 February 2007, in a rural community called Zurima (18º46'40''S, 65º07'40''W) in the department of Chuquisaca, I caught an adult female *E. chiriquinus* (MHNC-M 154) in a mist net that was set next to a light post along the road between the cities of Sucre and Cochabamba. The netting site was 33 km NNE of Sucre, at an elevation of 1,800 m. A second specimen, an adult male (MHNC-M 162), was captured on 23 March 2007, in Camp Humajalanta (18º06'52''S, 65º48'37''W) of the Parque Nacional Torotoro in the department of Potosi. The site was 87 km SE from Cochabamba, at an elevation of 2,830 m. The vegetation at both sites is classified as Dry Inter-Andean Forest, a highly heterogeneous and fragmented ecoregion that is characterized by advanced degradation due to human use (Ibisch et al., 2003).

External and cranial measurements of both specimens are generally within the range presented by Simmons and Voss (1998) for *E. chiriquinus*, although some measurements are slightly greater (Table 1). Similarly, the external and cranial morphology also conforms to the revised diagnosis by Simmons and Voss (1998). For example, dorsal hairs of the two Bolivian specimens are long (8–11 mm), and in life, the fur appears oily. Color of the dorsal hair is dark brown in one specimen and brown in the other. In addition, both skulls have well-developed sagittal and nuchal crests.

Eptesicus chiriquinus has been reported mainly from lowland forests in Costa Rica, Panama, Colombia, Ecuador, Peru, Venezuela, Guyana, French Guiana, and Amazonian Brazil (Simmons, 2005; Simmons and Voss, 1998). Therefore, the specimens from Bolivia are the southernmost records for the species. It is also noteworthy that the Bolivian sites are at high altitudes and in dry habitats, in contrast to most previous observations.

Previous reports indicated that the geographic range of *Eptesicus andinus* included Guyana, Venezuela, Colombia, Ecuador, Peru, Amazonian Brazil, and possibly Bolivia (Simmons, 2005). Anderson (1997) reported only one specimen from Bolivia that was identified as *E. andinus*. However, several other specimens were identified as *E. furinalis montosus*, a taxon

Table 1. Measurements of *Eptesicus andinus* and *Eptesicus chiriquinus* collected in Bolivia.

	Eptesicus chiriquinus		*Eptesicus andinus*	
	MHNC-M 154	MHNC-M 162	MHNC-M 140	Captured [b]
Sex	female	male	female	3 females, 1 male
Weight	14	16	9	10.75 (8–13 [a]) 4
Total length	114	117 [a]	85	93.25 (89–98) 4
Tail length	46	50	35	37.5 (32–44 [a]) 4
Hind foot length	12	10	9	8.5 (8–9) 4
Ear length	18 [a]	17	10	11.3 (9–15) 3
Forearm length	47.1	46.98	41.52	42.3 (41.06–42,82 [a]) 4
Greatest length of skull	17.98 [a]	17.76 [a]	14.74	
Condyloincisive length	17.34	16.84	14.5	
Postorbital breadth	3.92	4.12	4.24	
Zygomatic breadth	12.12	12.06	10.2	
Braincase breadth	7.84	7.82	7,16	
Mastoid breadth	8.84	9.72 [a]	8.24	
Maxillary toothrow length	7.1	6.7	5.9	
Breadth across molars	7.54	7.9 [a]	6.78	

[a] Measurements slightly larger than those presented by Simmons and Voss (1998).
[b] Summary statistics (mean, observed range, and sample size) of measurements for captured *E. andinus*.

that currently is believed to be included in *E. andinus* (Simmons and Voss, 1998), although these specimens have not been re-examined to determine their correct identification (Simmons, 2005).

On 19 January 2005, I captured three *E. andinus*, and one of these, a juvenile female, was preserved. The bats were mist-netted in Campos de Pinos (21º54’52’’S, 64º31’34’’W), in Reserva Tariquía, 47 km SE of Tarija, at an elevation of 1,780 m. Barquez et al. (1999) and Barquez and Díaz (2001) did not report *E. andinus* in Argentina; therefore, these records constitute the southernmost for the species. On 19 November 2005, I also captured two lactating *E. andinus* in Serranía Los Volcanes (18º06’42’’S, 63º36’08’’W), 57 km NW of Santa Cruz, at an elevation of 990 m. The vegetation at both sites is Tucuman-Bolivian forest (Ibisch et al., 2003). Although this is a naturally fragmented ecoregion, human activity is promoting conversion and additional fragmentation of the forest, making this one of the most threatened ecoregions in Bolivia (Ibisch et al., 2003).

Standard measurements and morphology of the collected specimen and other captured individuals of *E. andinus* (Table 1) are comparable to those presented by Simmons and Voss (1998) for this species. The new records that are reported herein, together with additional records presented by Terán (2004) and Vargas et al. (2005) for the Yungas ecoregion, confirm the presence of *E. andinus* in Bolivia.

Acknowledgments

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AUTHOR CORRECTION

In the article by N. E. Middleton, D. Dodds, C. Gould, C. R. Macadam, S. Mackenzie, and K. Morrison, entitled "A Technique for Surveying Bats in Narrow Habitat Corridors" (*Bat Research News*, 47:33–36), David Dodds has contacted the Editor to state that he was not a co-author of the paper nor did he contribute to designing the survey that was described in that paper.

Abstracts of Papers Presented at the

Royal Zoological Society of New South Wales and Australasian Bat Society Symposium on the Biology and Conservation of Australasian Bats

Sydney, NSW, Australia 12–14 April 2007

The following abstracts are from papers presented at the Royal Zoological Society of New South Wales and Australasian Bat Society's joint bat symposium. A very special note of thanks goes to the Royal Zoological Society of New South Wales (RZS of NSW), the Australasian Bat Society (ABS), and the organizers of the Symposium—Peggy Eby, Bradley Law, Lindy Lumsden, and Dan Lunney—for granting *Bat Research News* permission to publish these abstracts.

The RZS/ABS abstracts were compiled, edited, and submitted by Lindy Lumsden and Peggy Eby. During the preparation of abstracts for publication in *Bat Research News*, editorial and formatting changes were made by the Editor, Margaret Griffiths. Any errors that may have been introduced during this preparation are inadvertent, and she asks that you please accept her sincerest apologies.

Contact information for authors who attended the RZS/ABS meeting can be found in the list of meeting participants, which immediately follows the abstracts. The country for all addresses is Australia unless otherwise noted. Also please note that the Royal Zoological Society of New South Wales will publish papers presented at the Symposium as refereed chapters in a book of conference proceedings. If you are interested in purchasing the conference proceedings, please contact Dan Lunney or Brad Law, or see the RZS website (**http://www.rzsnsw.org.au**).

The current status of bats in Western Australia

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Understanding of the distribution and ecology of some Western Australian bats has advanced considerably in the last ten years, while knowledge of others remains basic. The state has one species listed in the highest conservation level under state legislation (*Rhinonicteris aurantia*), and one population of this species is listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Six other species are included on the Department of Environment and Conservation's Priority Fauna Listing based on their known distribution and representation on conservation and threatened lands (*Falsistrellus mackenziei*, *Hipposideros stenotis*, *Macroderma gigas*, *Mormopterus loriae cobourgiana*, *Nyctophilus timoriensis* [central form] and *Vespadelus douglasorum*). These listings mainly reflect lack of knowledge and perceived threat. Recent research on *R. aurantia* and *M. gigas* has provided much relevant information for assessing development proposals, mainly in the Pilbara where plans for iron and gold mines sometimes coincide with their habitat. Proactive consultative projects that address these issues were begun in the past few years and involve a variety of approaches from surveys and preservation of adits to genetic work. Some groups would benefit from taxonomic resolution especially *M. l. cobourgiana* and *N. timoriensis* given their current conservation status. Other more common species also require attention (e.g., *Vespadelus finlaysoni*, *Mormopterus* form sp.

4) and there is the possibility of a new species of *Vespadelus* in the Kimberley. The impact of logging, mining and other disturbances involving forest clearing in the southwest are largely unknown, but studies have begun. The status of cave occupancy of bats in southwest caves was recently assessed. A series of studies on aerodynamics, foraging strategy and call design has contributed much to the understanding of the ecology of WA bats. While keys are still unavailable for identifying bats from their echolocation calls, new methods are now available that help distinguish some species with similar call design.

Australian bat lyssavirus

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Abstract not available.

The impact of the drought on bats

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The population of southern bent-winged bats *Miniopterus schreibersii bassanii* at Naracoorte Caves has been the subject of many years of research. One facet of this research has been determining the population and how stable it is, after a significant decline was observed to have occurred between the 1965 estimate of over 100,000 and the 2000 count of 35,000. Investigations into possible causes have included chemical use in primary industry and changing land use in the region. The bats and their daily activities are observed and interpreted to visitors using infrared technology transmitting images from the Bat Cave to the Bat Observation Centre. Visits into the cave for camera maintenance and cleaning are the only non-research visits. It was during one of these camera-cleaning visits that the impacts of the dry and cold season on the bats' nursery were first observed. The nursery was established in a part of the cave not readily visible using the cameras. On a visit to the cave on 7 December, over 300 were counted dead or dying on the floor and dozens more were still hanging from the ceiling in an emaciated condition. Follow-up visits were made on 14 December when significant numbers were still dying and then again on 30 December, by which time the situation appeared normal. It is suggested the reason for the early deaths is likely to be the lack of insects brought about by the extremely dry conditions through winter and spring. This was further compounded by the record number of cold nights that further restricted insect activity at a critical time. This poster presents the impacts on the unseasonable conditions on the Bat Cave's population and links the weather observations with the observations from within the cave. It is suggested that continuing weather patterns of this nature will place the population at severe risk of further decline.

A risk assessment of the introduction of Nipah virus to Australia via flying foxes

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Flying foxes (genus *Pteropus*) are the natural hosts of several recently emerged zoonotic viruses of animal and human health significance in Australia and Asia. These include the newly

recognized paramyxoviruses Hendra virus and Nipah virus (NiV) (genus *Henipavirus*). Two of the putative natural hosts of NiV (*Pteropus vampyrus* and *P. hypomelanus*) are widespread in the Indomalayan archipelago and parts of New Guinea, where their ranges overlap with two species that occur in Australia (*P. alecto* and *P. conspicillatus*). Further, the clusters of NiV-associated disease that occur almost annually in humans in Bangladesh, with evidence of human-to-human transmission, highlight the need for a thorough understanding of the ecology of henipaviruses. This study aims to establish the geographic distribution of Nipah virus infection and level of contact among flying fox populations in the Australian border regions. Methods: (1) targeted serology and virology of flying fox populations using a serum neutralization test, multiplex microsphere assay, and viral RNA detection using realtime PCR; (2) molecular genetic investigation of the population structure of *P. alecto* throughout its range in Australia, Papua New Guinea, and Indonesia using analysis of mitochondrial DNA sequence data and nuclear DNA polymorphic microsatellite loci; (3) satellite telemetry of eight flying foxes in north Queensland, Western Province (PNG), and Timor-Leste. Preliminary results: (1) evidence of Nipah or a Nipah-like virus in flying foxes in Timor-Leste; (2) the sharing of multiple haplotype lineages of *P. alecto* between Australia and Lesser Sunda Islands with evidence of recent gene flow between regions; (3) movement of flying foxes between Australia and New Guinea. These preliminary results suggest a theoretical risk exists, and indicate the need for further work on the ecology of henipaviruses in the Australasian region.

Transmigrating pteropodids: international movements of flying foxes—implications for conservation and introduction of disease

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Human activities appear to be causing significant changes in flying fox distribution and behavior, bringing them into closer contact with domestic animals and people. Flying foxes are reservoir hosts for several recently emerged fatal zoonoses including Nipah virus (NiV), Hendra virus and Australian bat lyssavirus. NiV is exotic to Australia but present in southern and southeast Asia. The level of contact among flying fox populations in Australia, New Guinea and southeast Asia is currently unknown. The aim of this study was to track the long distance movements of flying foxes in Australia's border regions as part of a broader project to assess the risk of the introduction of NiV to Australia via flying foxes. Satellite transmitters were placed on eight flying foxes (four *Pteropus alecto*, two *P. vampyrus* and two *P. neohibernicus*) and their movements tracked for a total of 150 weeks. Six movements across political and putative ecological boundaries were made by the flying foxes. *P. alecto* moved between Australia and Papua New Guinea on four occasions, and between Papua New Guinea and Indonesian Papua on one occasion. *P. vampyrus* moved from Timor-Leste to Indonesian West Timor on one occasion. These results suggest a contiguous population of *P. alecto* exists in parts of north Queensland, Western Province (PNG) and Papua (Indonesia). This highlights the potential for close connectivity between flying fox populations on the Australian and New Guinean landmasses and associated political regions and hence the importance of international cooperation in disease risk management and conservation planning.

Foraging strategies and diet in the Australian Large-footed myotis, *Myotis macropus*

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Several myotis species glean insect prey directly from the water surface using echolocation, leading to speculation that they are capable of catching small fish at the surface. Such behavior in myotis has never been observed directly, and the only evidence for piscivory comes from the presence of fish scales in feces collected at roost sites for the species *Myotis macropus* from Australia and *M. ricketti* from China. This study is based on observations of *M. macropus* foraging over water at several sites in Queensland. Digital video recordings were made under infrared or red illumination and analyzed frame by frame, together with synchronized echolocation call recordings. By this method, it was possible to identify and categorize the strategies used by *M. macropus* when successfully capturing or attempt to capture prey, either above or on the water surface. *M. macropus* appears to be far more successful at capturing prey directly from the water surface compared to just above it, or even during regular aerial hawking. Video footage shows that *M. macropus* gaff prey off the water surface using only their feet. Bats were observed to periodically leave and return to their foraging areas, possibly to consume prey at a night roost. Hunting bats were captured in mist nets immediately downstream from their foraging area and feces collected for dietary analysis. Fecal pellets contained hundreds of fish scales (*Gambusia affinis, Pseudomugil signifer*), strongly suggesting that some of the video observations involved bats fishing. Further examination of the feces revealed the remains of atyid shrimps (*Paratya australiensis*), together with parts of waterborne insects such as whirligig beetles, water beetles, and mayflies.

Diet and movements of Grey-headed Flying Foxes (*Pteropus poliocephalus*) from a colony site at the Royal Botanic Gardens, Sydney

Neisha Burton, Kerryn Parry-Jones, Glenda Wardle, and Anja Divljan; University of Sydney, NSW 2000

The Royal Botanic Gardens in Sydney's CBD are the location of a colony of Grey-headed Flying Foxes. A study was conducted on this colony to determine its size, what the flying foxes ate and where they ate it. Over a number of catching sessions between February and August 2006, 125 Grey-headed and one Black Flying Foxes were caught in mist nets. Pollen and fecal samples were collected and analyzed to determine the bats' diet. Samples were collected from bats of known age and sex so analysis would reveal possible resource partitioning within the colony. Fly-out counts were conducted on a weekly basis to determine population size and how it changed over-time. To find out where the flying foxes went to feed, five grey-headed and one black flying fox were fitted with radio-collars and tracked to their foraging sites. All flying foxes had pollen on their fur, indicating blossom visitation. Myrtaceae pollen was found on 94% of animals and fig fruit was the most common food type in fecal samples. There were some notable differences in diet between males and females and juvenile and adult bats but these were not significant. Population numbers fluctuated weekly from 18,900 in the breeding season to 5,400 in winter. Movements of radio-collared bats indicated that they returned to the same foraging site each night and foraged within 5 km of the colony site. This study showed that Grey-headed Flying Foxes from the colony at the Royal Botanic Gardens Sydney eat a diet consisting of

native fruits and blossoms. They feed on these close to the colony site and show strong foraging-site loyalty.

Behavioral ecology and conservation of Australia's only trawling bat, the Large-footed Myotis: a review

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Amongst the myriad of microbat foraging modes, fishing and trawling behaviors have arisen multiple times in different phylogenetic clades. Whilst true piscivory is rare, several myotis species show morphological adaptations to aquatic foraging. The inclusion of fish into the diet of these species has the potential to influence life-history characteristics such as the use of torpor, migration, roost selection, and breeding ecology. Fishing and trawling bats also present unique conservation concerns: water quality impacts directly on both the availability and detectability of prey, and the roosting behavior of these species is often constrained by the vicinity of suitable waterways for foraging. The Large-footed Myotis, *Myotis macropus*, is morphologically and ecologically similar to overseas trawling species, and is Australia's only trawling microbat. Drought conditions are set to challenge *M. macropus*, with dramatic declines in the availability of suitable waterways and increased stress placed upon the remaining riparian vegetation. This review summarizes the current knowledge of the ecology of fishing and trawling bats and presents recent results on the foraging and roosting behavior of *M. macropus* in southeastern Australia. In Queensland *M. macropus* forms harems and has two breeding seasons per year. There is also evidence of two birthing periods in southern Australia. *M. macropus* forages almost exclusively over water and regularly preys upon aquatic invertebrates and fish. Furthermore, *M. macropus* roosts in a variety of structures that have suitable thermal microclimates and are located within 100 m of foraging grounds. The obligate relationship between *M. macropus* and permanent waterways warns of impeding conservation challenges in the face of ongoing climate change.

Recent Anabat developments

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Anabat is an acoustic bat-detection system using frequency division and zero-crossings analysis to efficiently detect and analyze ultrasonic bat calls. Because of its highly optimized data processing and management, it is ideally suited to both long-term passive monitoring and production of real-time sonograms. Recent developments include synchronized arrays for plotting bat positions in three dimensions, highly portable PDA-based systems for active monitoring, and automated data scanning software for automated species identification. A synchronized array of detectors uses signal times-of-arrival to determine the position of a bat each time it calls. This system has already been used to measure call intensities of wild bats. Other potential uses include plotting the trajectories of bats near wind turbines, and determination of flight direction at a cave entrance. Active monitoring using a PDA-based system has proven extremely effective. A bat detector and PDA, providing real-time Anabat displays, can be held in one hand. This system has practical advantages over heterodyne and time-expansion systems, providing useful output from even a single bat call. In field comparisons, any deficit in sensitivity was more than compensated for by a real-time, broadband, visual display, and freedom from the need for specialized hearing skills. Automated scanning of

passively-collected Anabat data has been possible for some time. A much more user-friendly version has now been implemented as part of the AnalookW software package, and this will make automated analysis of large datasets much easier and more reliable.

Studies on damage caused by Grey-headed Flying Foxes (GHFF) and factors affecting their influx into fruit orchards in the Sydney Basin

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A collaborative project to determine the economic losses in orchards caused by Grey-headed Flying Foxes (GHFF) and the internal and external factors of the orchards and GHFF behavior affecting the damage levels has commenced in the Sydney Basin. The study is funded by Australian Government Natural Heritage Trust (NHT) Strategic Reserve funding, NSW Department of Environment Conservation (DEC) cash and in-kind contributions, and NSW Department of Primary Industries (DPI) in-kind contributions, and addresses several recovery actions of the draft National Recovery Plan for the GHFF. The project was also strongly supported by the NSW Flying-fox Consultative Committee. Preliminary assessments conducted in orchards in Bilpin and the Southern Highlands indicate that GHFF could cause significant yield loss in orchards without netting. In another trial, fruit loss caused by GHFF removal of fruit and damage of fruit on trees was monitored before harvest. Up to10% of fruits were taken away and 3% of fruit were damaged during the three-week period. Estimates of damage during harvest are ongoing. Surveys of GHFF visiting orchards were conducted from early November 2006 to February 2007. Results show that there was significant difference between flying fox activity in different regions in the Sydney Basin: Kurajong and the Southern Highlands had lower GHFF activity than Bilpin and Glenorie. Continuing work will determine the cost-effectiveness of netting as a strategy to control GHFF damage in orchards. The contribution of orchard design and location variables, and external factors to damage experienced in orchards will be modeled.

A hundred-and-forty days in the life of a flying fox tooth-fairy: estimating the age of pups using tooth eruption and replacement

Anja Divljan, Kerryn Parry-Jones, and Glenda M. Wardle; Institute of Wildlife Research, University of Sydney, NSW 2000

Age can be an important predictor of an individual's survival or reproductive fate, and therefore methods for determining ages of wild animals are of general interest. Bats are assigned to age classes based on morphological measurements (e.g. forearm measurement and tooth wear); or to a chronological year based on annual cementum rings in teeth. However, for infants, only morphometric techniques are available, and individual variation can lead to less reliable predictions of age from these measurements. Here we describe the sequences and timing of tooth emergence and replacement in the Grey-headed Flying Fox (*Pteropus poliocephalus*) and evaluate the usefulness of the method for ageing pups. Tooth eruption and replacement were assessed visually and at least four stages of growth were described for each permanent tooth for 27 known-age, mother-reared pups (18 in 2005/2006 and 9 in 2006/2007) that were monitored weekly (October–February). Forearm measurements and mass were also recorded. To test the reliability of the method, we also aged 30 additional pups. The ages derived from tooth eruption were compared to ages derived from the traditional method using forearm and weight measurements. Our results indicate that the tooth eruption technique is more reliable in estimating flying fox age up to 140 days old. Further research should compare rates and patterns of tooth eruption in hand-raised to mother-raised pups and use a larger sample size to look for any gender differences. Accurate ages for pups will contribute to determining the age-specific mortality rates for this vulnerable species.

Status and conservation of bats in Tasmania

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Compared with mainland Australia, the diversity of bats in Tasmania is low. In all, there are eight species of native bats recorded in Tasmania: Gould’s Wattled Bat, *Chalinolobus gouldii*; Chocolate Wattled Bat, *C. morio*; Large Forest Bat, *Vespadelus darlingtoni*; Southern Forest Bat, *Vespadelus regulus*; Little Forest Bat, *Vespadelus vulturnus*; Eastern False Pipistrelle, *Falsistrellus tasmaniensis*; Lesser Long-eared Bat, *Nyctophilus geoffroyi*; and Greater Long-eared Bat, *N. timoriensis*. There has been a limited amount of bat research and survey in Tasmania and systematic surveys have not been undertaken across Tasmania. However, all species appear to be widely distributed and none are listed under Tasmania's *Threatened Species Protection Act 1995.*

Nectar maps for Grey-headed Flying Foxes: describing seasonal dynamics and identifying key habitats

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Complex relationships between the flowering characteristics and distribution of plants in the diet of Grey-headed Flying Foxes (GHFF) make it difficult to explore the processes that underlie resource dynamics and identify key habitats for conservation. The aims of this project were: to develop a systematic method for evaluating flowering characteristics and distributions using existing data; and to use the method to describe resource dynamics and rank vegetation communities according to their significance for GHFF. Five attributes were used to define the productivity of diet plants, and the annual reliability and duration of flowering events. Data were gathered from a range of sources and collapsed into three or four scores per attribute to accommodate differences in methods of collection. In addition, the seasonal flowering schedules of plants were recorded at bi-monthly intervals. Plant communities described in GIS vegetation models were used to define habitats, calculate the relative densities and distributions of diet plants, explore spatial and temporal patterns at geographic scales, and generate nectar maps. The species richness of diet plants and the extent of feeding habitat for GHFFs decrease along a latitudinal gradient and with increasing distance from the coast. The richness of highly productive plants varies in line with patterns of overall species richness. However, richness of plants with reliable flowering patterns decrease across the gradients at greater rates, generating unreliable feeding landscapes in southern and inland areas. The factors that support seasonal food resources vary. For example, summer-flowering species characteristically show a low degree of reliability, which is apparently compensated for by widespread distributions and high species richness in local areas. By contrast, high levels of reliability and productivity in winter-flowering plants are moderated by low species richness and restricted distributions. These results are in keeping with our understanding of annual patterns of winter concentration and summer dispersal in GHFF and suggest that the extent of nomadism varies between seasons.

Roosting in suburban Melbourne: bat boxes versus tree hollows
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Bats living in Melbourne's suburbs face a number of challenges including high concentrations of introduced predators such as domestic cats, increased disturbance, and limited natural roosts. In the last ten years, nest boxes have increasingly become a management tool to provide additional hollows for bats in suburban parkland and remnant forest. At Gresswell Wildlife Reserve in the suburb of Bundoora, there are both natural hollows and bat boxes available to a population of Gould's Wattled Bats (*Chalinolobus gouldii*). The aim of this study was to investigate the relative use of the two alternate roost types, and determine if there were intra-specific differences. We used radio telemetry to locate the roost sites of six male and nine female bats, initially caught in bat boxes in January and February 2007. Roosts were found in eleven bat boxes and seven natural hollows. Both sexes used natural roosts and bat boxes, although there was a trend for females to use more of the available natural hollows than males. Roost-fidelity was variable, with some individuals shifting regularly while others stayed in the same roost for up to 15 days. Animals using boxes tended to shift roosts less often than when in hollows, especially when compared to data collected for *C. gouldii* using natural roosts in rural landscapes of northern Victoria. Suburban development changes the distribution of resources available to bats and this may influence their roosting behavior and have consequences for social interactions, predation and parasite loads.

"Bats In Your Backyard" project: a baseline monitoring project for the Northern and Yorke Region of South Australia
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"Bats in Your Backyard" is a new project being managed by the South Australia (SA) Department for Environment and Heritage (DEH) in Clare. The project has been developed to collect baseline data on the presence and distribution of microbats across the Northern and Yorke Region. Data will be collected using harp traps and Anabat equipment. The Northern and Yorke Region of South Australia covers the State's Mid North, Flinders and Yorke Peninsula districts, an area of some 9,800,000 hectares. There has been extensive clearance of vegetation across the Region, primarily for agricultural production. The remaining native vegetation generally comprises relatively small patches, within a highly fragmented landscape. The impact of habitat loss and modification on local microbat species is not well understood. The project was developed in 2006 with staff input from DEH, the Northern and Yorke NRM Board, and SA Museum. The project will initially focus on the determining the distribution of microbats across the Region and an examination of what natural and artificial habitats are being utilized. Once baseline data have been collected, an assessment of the effects of habitat loss and fragmentation on the local microbat fauna will be undertaken. There is strong community support for the

project. Local community groups, community members, and landholders will be involved in the collection of data. This will provide a strong base upon which conservation initiatives can be developed.

Hendra virus: ecosystem disruption and disease emergence
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Flying foxes (*Pteropus* spp.) have been identified as natural hosts of henipaviruses, a previously unknown group of viruses responsible for fatal disease outbreaks in livestock and/or humans. There are two members of the genus: Hendra virus, first described in 1994 in Australia; and Nipah virus, first described in Malaysia in 1999, and currently causing annual outbreaks of encephalitic disease in humans in Bangladesh. The emergence of these viruses is widely recognized as due to an increased probability of contact between flying foxes and livestock/human populations as a result of land-use, climatic and demographic changes. There is evidence that such changes are altering the structure and dynamics of flying fox populations in Australia, and we contend that a resultant altered pattern of Hendra virus infection in flying foxes increases the probability of spillover events, and determines the spatial and temporal pattern of these events. Specifically, our modeling has shown that increasing fragmentation and isolation of flying fox populations favors larger outbreaks in flying foxes, and thus increased opportunity of exposure and infection of spillover hosts.

Operant conditioning of the Spectacled Flying Fox (*Pteropus conspicillatus*)
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Behavioral research with flying foxes is difficult to conduct under natural conditions in the wild, and only one laboratory behavioral study (of flying fox visual acuity) has been reported in the literature. In this free operant conditioning study, ten tame Spectacled Flying Foxes (*Pteropus conspicillatus*) had to learn to pull levers for a juice reward in the controlled environment of a modified Skinner box. All sessions were monitored and recorded on video. The learning behavior of the three hand-raised animals was dramatically different to that of the seven wild-raised subjects. The three hand-raised flying foxes made the association between the lever-pulling and the juice-reward in the seventh, ninth or fourteenth 10-minute session. However, the wild-raised animals did not learn this even after 15 trial sessions. In the reacquisition phase the three hand-raised subjects pulled the levers for a juice reward after a latency phase of only 30 to 65 seconds showing that learning had taken place. Great individual differences in behavior of the three 'learners' were observed during the extinction phase, which ranged from frantic lever pulling to quiet grooming. Two explanations for the difference in learning between the hand- and wild-raised flying foxes are advanced. The mild liquid deprivation of five to seven hours prior to the conditioning trials in the late afternoon was not enough to elicit strong searching behavior. Severe food deprivation has been shown to work for wild *P. giganteus*. Taking into consideration the close evolutionary relationship between flying foxes and lemurs, observation studies of lemurs may provide a parallel. In lemurs, inquisitiveness toward non-food items was surprisingly low and was explained by the social environment in which the young learn by imitating the other group members. In hand-raised flying foxes the social environment is highly 'enriched' and the animals are exposed to a wide range of 'artificial' objects and stimuli, so that the animals in this study were pre-conditioned to the experimental environment. Studies with flying foxes that give insight into their learning behavior can be of great benefit when devising strategies for their management in the wild.

From Action Plan to Regional Action: a review of bat conservation in Queensland

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The Action Plan for Australian Bats recognized a total of 90 Australian taxa and of these, 69 or 77% occur in Queensland. Since the publication of the Action Plan, taxonomic reviews and other changes have altered these figures slightly, so that if we exclude one extinct species (*Pteropus brunneus*), remove subspecies from the equation and recognize a number of other taxa that are generally regarded as good species, then the numbers approximate 64 species in Queensland out of approximately 78 species in Australia, or 82%. In either case the proportion is high, which is not surprising, considering the size of the State and the range of environments encompassed. At the time of the Action Plan, Queensland was recognized as having seven taxa with Threatened Species status. Major threatening processes included tree-clearing, the destruction or disturbance of cave and mine roost and maternity and habitat alteration through changed fire regimes or grazing. Other species-specific threats included crop protection systems at orchards for several *Pteropus* species. Since that time, targeted research, wildlife surveys, advances in taxonomy and even anecdotal observations have altered our perceptions of the conservation status of many species. Progress has also been made in terms of conservation planning and the mitigation of threatening processes. Recent legislation has significantly reduced tree-clearing operations and new approaches have been developed at the State and Regional levels to more effectively target other threatening processes. Even so, the greatest problem confronting bat conservationists is a lack of detailed knowledge of species' biological and population parameters. Some past conservation programs are reviewed in this context and future recommendations are proposed.

A genetic perspective on the Spectacled Flying Fox, *Pteropus conspicillatus*

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The Spectacled Flying Fox (*Pteropus conspicillatus*) was listed as vulnerable under the EPBC Act in 2002, even though the Action Plan for Australian Bats stated that there was insufficient knowledge on this species to accurately assess its status. To aid in the effective management of the Spectacled Flying Fox, a genetic and demographic study was undertaken to supply baseline information derived from population genetic structure, genetic diversity, gene flow, relatedness within colonies, population age structure, and movement patterns. Here, we present the results from genetic analyses conducted on samples obtained from across the majority of the range of the Spectacled Flying Fox. Samples consisted of a small amount of wing membrane that came from animals from a variety of sources including many that had died from tick paralysis on the Atherton Tablelands. As expected, colonies within the Wet Tropics World Heritage Area can be considered a single panmictic population. However, while there has been movement between colonies in the Wet Tropics, Iron Range, and Papua New Guinea in the past, the data indicate that there have been periods of isolation, such as appears to be occurring currently. Calculation of genetic relatedness based on the multilocus genotypes among individuals within Powley Rd. colony suggested that groups of closely related individuals could be found together in the same colony, with the group often consisting of several older females, young from that year, and immature sub-adults from previous years. This suggests sub-adults may stay with their mothers for several years, learning the location of important foraging places across time and space. Genetic analysis has allowed a different perspective on the biology of these important animals.

Rabies prevention, and post-exposure management

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Human rabies is a disease transmitted mainly from bites from infected animal species. Dogs in the developing world represent the greatest risk for transmission, although Australia has a lyssavirus present among various bat species. Two human deaths from this Australian Bat Lyssavirus have been recorded. The risk to individual Australians is low, but bat-handlers within Australia, and international travelers are at increased risk. Some occupations—laboratory and research workers who may work with live virus—may be at high risk. Prevention for individuals involves an understanding of risk and avoidance of vectors, the routine use of post-exposure prophylaxis, and consideration of pre-exposure prophylactic immunization. A second rabies vaccine for post-exposure prophylaxis and for pre-exposure immunization has become available. Australians who work with bats, those who work with rabies virus, and medical practitioners need to be familiar with the preventive strategies and vaccines.

Can radar technology overcome the current limitations of surveying for Southern Bent-winged Bats, *Miniopterus schreibersii bassanii* at wind farms?

Rob Gration; Newport VIC 3015

The southwest region of Victoria is currently experiencing rapid growth in the number of proposed wind farms. A maternity roost and an unknown number of staging and winter roosts of the EPBC Act 1999 and FFG Act 1988 listed Southern Bent-winged Bat *Miniopterus schreibersii bassanii* are in the region. Bat detectors have been the primary tool used to survey for their presence at a proposed wind farm; however it was acknowledged by government agencies overseeing the EIS process that both the survey effort and design were lacking. This was recently addressed with the development of "Guidelines for bat survey in relation to wind farms." My recent experience with the guidelines was that they are very effective in identifying most species present and provide information on habitat use. They do not, however, overcome the technical limitations of undertaking targeted surveys for Southern Bent-winged Bats. These limitations are: identification based on call signature is unresolved; cannot quantify the number of bats utilizing a site; the volume of area a bat detector monitors is limited; and placing the bat detector at bat utilization height is problematic. This presentation will provide an overview on the use of radar technology and its potential to provide meaningful information on the numbers and site utilization of Southern Bent-winged Bats.

Hyoid Morphology of Bats of the Families Craseonycteridae, Hipposideridae, and Rhinolophidae (Chiroptera)

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The hyoid musculature, hyoid apparatus, and adjacent anatomy of the bumblebee bat, *Craseonycteris thonglongyai*, and of a taxonomically and geographically broad sample of hipposiderid and rhinolophid bat species are described and illustrated in detail. Data gathered are compared with data on hyoid and adjacent morphologies of bat families described elsewhere, using outgroup hyoid morphology data from (1) tree shrews (Scandentia) and flying lemurs (Dermoptera); and (2) horses (Perissodactyla) and dogs (Carnivora). Craseonycterid bats possess a number of morphological character states that are clearly derived and that have been described previously only in rhinopomatid bats, supporting a close phylogenetic relationship between the families Craseonycteridae and Rhinopomatidae. Cladistical analysis of craseonycterid, emballonurid, hipposiderid, megadermatid, nycterid, pteropodid, rhinolophid, and rhinopomatid bats suggests that rhinolophids and hipposiderids belong in a clade that also contains pteropodids, but this result should be treated with caution, as hyoid data on pteropodids are taken mostly from imperfect and incomplete descriptions in the literature. Relationships of other bat families are less certain. Megadermatids probably are the sister group to the rhinolophid-hipposiderid-pteropodid clade. Emballonurids may be the sister group of craseonycterids-rhinopomatids. At this point in our study, nycterids do not show a clear affinity for any other family analyzed.

How did you get interested in bats?

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The title of this paper is a question that is frequently asked to all people who work with bats, and one that has been put to me many times since I first became interested in bats in 1960. In this paper I will attempt to answer this question by relating to people and situations in my life that have led to my total devotion to this wonderful group of mammals. The major influence in my lifetime involvement with bats was joining the CSIRO, Division of Wildlife Research in 1962. It was here that a number of staff fostered my interest and jointly we began recording our early observations on Australian bats. At that time, the list of recognized bat species for Australia was only fifty. This made identification of species very easy for a novice bat researcher. There was a wonderful species called *Eptesicus pumilus* into which all small brown bats were placed. This group of bats now comprises the genus *Vespadelus* and currently contains nine species. Studying bats for over forty years has taken me to some interesting places and given me memorable experiences. It has been a very fulfilling and rewarding experience. A lot has been achieved by the collective efforts of Australian bat workers. However, there is still much to learn about their biology and conservation. This is a challenging task and one that can easily become a passion and consume your life.

Reflections on the evolution of bat research

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This paper combines personal experience with a more objective overview of bat research in Australia from 1954 to the present day and even venturing into probable futures. It starts with a handful of virtually self-taught researchers who developed a significant ecological and behavioral understanding through systematic observation. Simple technologies such as bat banding, and Constantine traps were a great leap forward. Today research faces a potential problem in the immense blossoming of electronic technologies that enable us to measure and record almost anything, but it may fail to genuinely increase our understanding. It may also overlook issues of respect and care for the animals who share in our research. Finally, in an era of environmental change, bats may yet provide valuable early-warning systems.

The Riversleigh fossil bat record: a review

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In 1976, Henk Godthelp and Mike Archer, then of the Queensland Museum, discovered Microsite, a 20 million-year old bat-bearing limestone deposit on Riversleigh Station, northwestern Queensland. Less than 20 m diameter and possibly 1 m deep, Microsite contained many thousands of tiny bat bones, representing the first-known Tertiary bat assemblage in Australia. This deposit turned out to be the first of many subsequently found at Riversleigh. The additional deposits were found throughout an area of 40 sq km and included late Oligocene, early, middle and late Miocene, early Pliocene and Quaternary bat-rich assemblages. Thirty years on from that first discovery, over 300 different fossil accumulations, almost all including bats, have been recorded and sampled in what is now the Australian Fossil Mammals World Heritage Site (Riversleigh-Naracoorte). This paper will review the principal outcomes of fossil bat research at Riversleigh—the problems solved as well as the many challenges that remain.

***Pteropus*, pestilence and politics—managing flying foxes in an inane environment**

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Managing flying fox colonies is no less challenging now than ever before but the expectations of the community have risen to an all time high. Colonies of flying foxes seem to find urban campsites more desirable than those in isolated areas and whilst we can’t seem to understand the reasoning, we need to look more into integrating information systems that can provide modeling data to assist us in undertaking more accurate assessments of the potential impacts of flying foxes on communities. Broad community support for the existence of flying foxes is virtually non-existent as the falsehood of the extent of zoonotic diseases is perpetuated and fictionalized into folklore. Government agencies are forced, as a consequence, to deal with the perceptions of the community rather than managing the realities of the issue. Community education programs are ignored in favor of actions and retributions against either the flying fox or the agency responsible for its management.

Survey of bats on Norfolk Island

Glenn Hoye; Fly By Night Bat Surveys PL, Belmont NSW 2280

Nothing is known of the bat fauna of Norfolk Island at the time of European discovery and settlement in the late 18th century. The East Coast Free-tailed Bat (*Mormopterus norfolkensis*) was described from a specimen in 1939. Doubts exist over whether the specimen was actually from Norfolk Island or elsewhere. Gould's Wattled Bat (*Chalinolobus gouldii*) was recorded from the island in 1915. I undertook an initial survey for bats on the island in February 1986 using harp traps and mist nets. A second survey utilizing Anabat detectors at thirty sites for a total of 260 hours of sampling was undertaken in February/March 2003. Sites were distributed throughout the island including residential areas, rural settings and remnant forest. In addition, island residents were questioned regarding their knowledge of bats. The results of the surveys are discussed.

Roosting and social behavior of the East Coast Free-tailed Bat *Mormopterus norfolkensis* in eastern New South Wales

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The East Coast Free-tailed Bat is a poorly known bat species occurring largely coastally from southern New South Wales to southeastern Queensland. Little is known of its roost preferences, social behavior, reproductive strategies, or diet. Within its range it has been captured sporadically, but has been more commonly recorded from echolocation calls in the last two decades. Individual East Coast Free-tailed Bats were radio-tracked to diurnal roosts at two sites in eastern New South Wales when individuals became available through targeted capture or through roost disturbance. Characteristics of identified roost trees were noted together with their placement in the landscape. At one of the sites this species has utilized artificial roost boxes for the past seven years. This has allowed some aspects of social structure to be recorded during regular inspections of the boxes.

Recent amendments to the Environment Protection and Biodiversity Conservation Act 1999 and their relevance to bat conservation

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The most recent amendments to the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) commenced on 19 February 2007. These amendments provide, among other things, greater flexibility in the assessment and referral process, establish a new process for listing threatened species, ecological communities and key threatening processes, and enhance the EPBC Act's compliance and enforcement regime. Of particular relevance to bat conservation are the new procedures that relate to the listing and recovery of threatened species and ecological communities. New procedures include the formulation of a prioritization list for nominations, the possible adoption by the Minister of a conservation theme for new nominations and the establishment of an annual assessment cycle. The new process is designed to improve the effectiveness of listing with a more strategic approach focusing on those species in greatest need of protection. The amendments change the focus from recovery plans to recovery 'action', primarily through ensuring that there is approved conservation advice at all times for each listed threatened species and ecological community. The Minister can decide whether a recovery plan

is required for a threatened species or ecological community or whether to discontinue use of an existing plan. The changes to the EPBC Act will ensure that matters protected by the Act continue to receive the highest possible level of protection. Implementation of these changes will cut unproductive 'red tape' and enable quicker and more strategic action to be taken on emerging environmental issues.

Grey-headed Flying Foxes drinking

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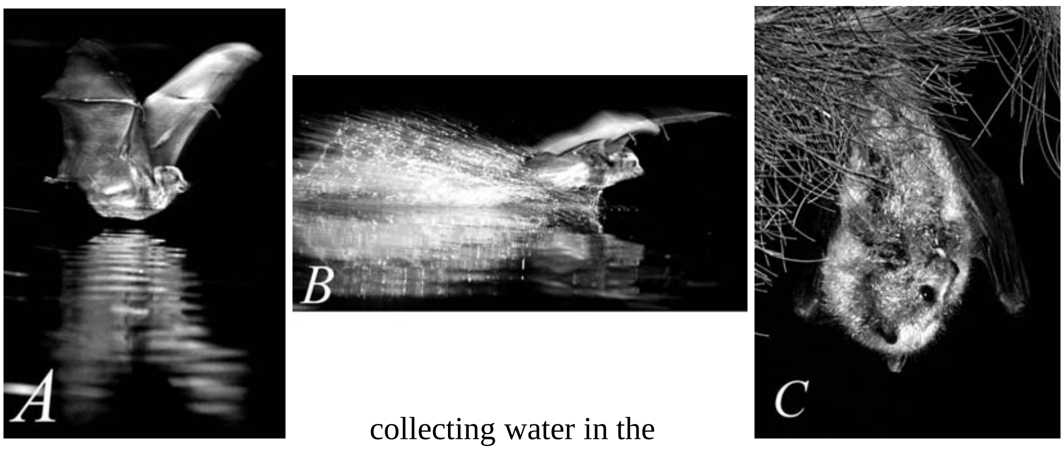

collecting water in the belly fur

drinking

The prey-predator relationship between field crickets (*Teleogryllus* spp.) and echolocating bats in Australia

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In the predator-prey relationship between bats and insects, Australian field crickets (*Teleogryllus* spp.) have become a model system. On the sensory side, neural processing of ultrasound by the field cricket auditory system is well known although behaviorally, experiments have relied on tethered animals responding to artificial 'bat-like' stimuli. At present, there is no direct evidence that bats prey upon *Teleogryllus* spp. in nature, and that their ultrasound (bat) avoidance behavior has any real adaptive significance. To put ultrasound avoidance behavior into a more natural context, the response of unrestrained (walking) *Teleogryllus commodus* has been studied in the laboratory, by replaying pre-recorded bat echolocation calls. The calls come from species of Australian bats likely to be the natural predators of field crickets; a range of artificial bat-like ultrasonic pulses has been tested as well. Digital video analysis of cricket walking behavior reveals that avoidance (negative phonotaxis) depends on the type of stimulus (artificial or real bat call) in terms of effectiveness. Experimentally, pulse repetition rate needs to be above 20 pulses per second (pps) to initiate an escape response, with a specific freeze behavior induced at rates above 60 pps. These rates are consistent with natural bat attack sequences. Replaying real bat echolocation calls suggests that there may be a difference in the potency of signals between bat species, with the calls of *Nyctophilus* spp. being particularly effective at inducing the escape response. The exact scenario under which field crickets are captured in the field by Australian bats remains to be determined. However the distribution of field crickets and their potential predatory bat species overlap in certain regions of Australia.

Do ephemeral streams in the Pilliga forests support a characteristic bat community?

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Riparian zones potentially provide very important habitat for microbats. In forests subject to logging, buffers are normally retained along streams to maintain water quality and protect riparian vegetation and its associated fauna. In the Pilliga State Forests of northwest NSW, streams are ephemeral ranging in size from shallow depressions to sand rivers more than 80 m across. We sampled bats as part of a broader program to assess biodiversity around ephemeral streams and to investigate: (1) the importance of riparian zones to bats; (2) if there is a distinct bat community along riparian zones; (3) the distance away from streams at which this community changes; and (4) whether this distance varies with stream order. Anabat detectors recorded bat activity over two consecutive nights at each of three stream sizes (small, medium, and large), clustered into five different locations (replicates). Anabats were placed at varying distance perpendicular from the dry, streambed center (0 m, 50 m, 100 m, 200 m). To assess the influence on bat activity of the flyway per se versus the riparian zone, one cluster of sites represented a control or reference that comprised dirt roads of different sizes. Over the course of the study 20,472 bat calls were recorded from 15 species. A multivariate analysis (nmds) of species composition indicated that there was no distinct bat community characteristic of the riparian zone. Overall, bat activity was weakly influenced by stream size and the perpendicular distance from the stream did not influence activity. However, there was a significant interaction between distance and stream size, with large streams supporting three times more activity over the channels than adjacent woodland. A similar, but non-significant trend was evident for medium streams, but not small streams, which usually lacked a distinct flyway. Similarly for reference sites, the largest road supported more activity directly over the road than adjacent woodland. Thus the higher activity found for some linear flyways was mostly related to the lack of clutter, and to a lesser extent the higher productivity of riparian zones. Responses of individual species will also be examined.

Preliminary analysis of microbat surveys of Cumberland Plain reserves

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Microchiroptera were surveyed with harp traps and Anabat system at 191 sites in reserves on/adjacent to the Cumberland Plain, western Sydney. Six hundred and forty-seven individuals were trapped and 2069 echolocation sequences were recorded of 16 species. The two most commonly caught species were *Vespadelus vulturnus* (31%) and *Nyctophilus geoffroyi* (26%). The species recorded at the most sites with Anabat were *Chalinolobus gouldii* (54%), *V. vulturnus* (45%), *Mormopterus* sp. 2 (34%), and *M. norfolkensis* (32%). The latter two species were infrequently captured. The overall mean number of captures per trap night was low (1.33±0.19; range 0–22). The mean number of species/site was 1.27±0.09 (trapping: range 0–7) and 2.67±0.15 (Anabat: range 0–9). The sex ratio was female biased at Agnes Banks NR (χ^2 = 7.48; 1df; p < 0.01), Castlereagh NR (χ^2 = 13.32; 1df; p < 0.01), and Cattai NP (χ^2 = 8.27; 1df; p < 0.01). All of these reserves have many old hollow-bearing trees and relatively large intact bushland adjacent. For the two most common bats there was no difference in the weight and condition of adult males between reserves, suggesting that poorer quality habitats do not have animals in poorer condition. There was a significant correlation between the mean number of species/site and vegetation within 3 km ($r^2 = 0.43$; $F = 7.363$; $p < 0.05$), and the mean number of individuals/site and vegetation within 3 km ($r^2 = 0.58$; $F = 13.9$; $p < 0.01$). This has long term implications for western Sydney's microbat populations as further urban development occurs. This study suggests that whilst western Sydney reserves still support a diverse microbat fauna, the fate of these bat populations is by no means secure.

Population changes in a bat community in the mangrove swamp forests in the Kikori River delta, Papua New Guinea

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Bat communities in the mangrove swamp forests of the Iviri and Keboi Kerowa area in the Kikori River delta were periodically monitored with mist nets between November 1998 and December 2004. A total of 435 individuals of 12 species of bat were captured. *Macroglossus minimus* constituted 90% of captures. The population fluctuated with an almost 11-fold difference between the peak and its lowest point. Bat numbers were correlated with cumulative monthly rainfall residual (CMRR) with a time lag of three ($r^2 = 0.63$; $F = 5.82$; $p < 0.05$) to four months ($r^2 = 0.63$; $F = 5.89$; $p < 0.05$). There was a significant correlation between a subjective bat flower abundance score and the mean captures of *M. minimus* per netting period ($r^2 = 0.64$; $F = 6.255$; $p < 0.05$). Flowering peaks on a phenology transect tended to be highly variable between years, but were generally during the drier season. Sixteen opportunistically sampled *M. minimus* were found to be carrying substantial pollen loads of at least six species. Reproductively active females and juvenile *M. minimus* were caught in all netting periods. In general though, a greater proportion of the population were juveniles in the dry season ($\chi^2 = 15.68$; 1df; $p < 0.001$), suggesting that some degree of synchrony in reproduction related to rainfall and food availability may occur. The results of this study suggest that rainfall and abundance of food has an important influence on population dynamics of *M. minimus* over long time periods and that food supply is not stable and predictable even in tropical areas with high rainfall.

Echolocation calls of eight microchiroptera from Papua New Guinea

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The bat fauna of Papua New Guinea (PNG) is more diverse than that of Australia, yet knowledge of the distribution and ecology of PNG's 57 microchiropteran species is particularly poor, almost a third being known from five or less localities. The lack of knowledge is partly due to problems with use of both mist nets and harp traps in PNG. Bat detectors may help overcome some of these problems; however they have not been widely used in PNG primarily due to the lack of a body of reference calls to aid identification of species. We recorded 744 reference echolocation call sequences from eight microchiropteran species captured in PNG using the Anabat system. Calls were analyzed using Analook software and described. The characteristic frequency of the predominant harmonics were: *Aselliscus tricuspidatus* 112–113 kHz;

Hipposideros cervinus 136.5–138 kHz; *H. diadema* 54–59 kHz; *H. maggietaylorae* 121–123 kHz; *Mormopterus* cf *beccarii* 44–50 kHz; *Mosia nigrescens* 45–60 kHz; *Rhinolophus arcuatus* 70–72 kHz; and *R. euryotis* 52–56 kHz. Comparisons with published calls of some of these species from Australia, southeast Asia and elsewhere in PNG suggest regional variations occur within PNG and abroad and/or that there are taxonomic issues such as cryptic species. This emphasizes the need for the development of regional PNG call libraries with vouchered specimens and cautions against using reference libraries developed in Australia or elsewhere. We hope this research will stimulate researchers to begin collecting reference echolocation calls of PNG bats, as the use of bat detectors in PNG would undoubtedly increase the known distribution of many species.

The composition and diversity of bat assemblages in different settings of the raised coral reef tropical forest of Taiwan

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We investigated the species composition, diversity, and seasonal variations of bat assemblages in the uplifted coral reef tropical forest of Taiwan. A total of 584 bats of 10 species was mist-netted, which accounts for one third of the bat fauna of this island. *Miniopterus schreibersii*, *Hipposideros terasensis*, *Rhinolophus formosae*, and *Murina puta* were the most frequently caught and abundant species, together accounting for 79% of the relative frequency and 84% of the relative abundance; followed by *R. monoceros* and *Myotis taiwanensis*. Both the total and mean numbers of species caught peaked in May–June, whereas the mean capture rates climaxed in July–August. Most species were captured year-round; *M. puta* appeared to be more abundant in winter, whereas *M. taiwanensis* was absent during late summer-early winter. The numbers of species present at interior and edge sites were similar, as were the species composition, and evenness and heterogeneity values. Capture rates, however, were two-fold higher at interior than edge sites, in particular for *H. terasensis*, *R. monoceros*, and *M. taiwanensis*; and were female-skewed, particularly for *M. schreibersi* and *R. monoceros*. The overall similarity in the species composition between the forest interior and edge sites, based on assessments of bat captures or bat passes, was nearly 10% higher than the similarity between data of bat captures and bat passes within the forest interior and edge sites, respectively.

Murray Region Community Bat Monitoring Program

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The Mid Murray Local Action Planning Committee (Mid Murray LAP) has been part of the community bat monitoring program, Bats for Biodiversity, since 2003. Bats for Biodiversity began as a community project known as Batwatch, started in 2001 and based in the Mt. Lofty Ranges. The project involved community members taking an Anabat home for the night to record the species on their properties. The Batwatch program was the first of its kind in Australia. In 2004, the Upper River Torrens Landcare Group and the Mount Pleasant Natural Resource Centre received an Australian Government Envirofund grant to allow Batwatch to grow and develop into the Bats for Biodiversity program it is today. The grant helped these groups to coordinate the bat monitoring that was occurring throughout the region and to produce

a manual to standardize the monitoring process. Information sheets were also produced to encourage local landholders to conserve and improve bat habitat. The Mid Murray LAP's role within the bat monitoring program has grown since their first involvement. It began with the purchase of an Anabat recorder in 2004 that was loaned to landholders in the Murray region. These recordings were analyzed by Mount Pleasant Natural Resource Centre and then sent to the South Australian Museum for confirmation and storage on their database. In 2005 the Mid Murray LAP purchased a further two Anabat recorders as public interest in the program increased. An Implementation Officer was employed with funds from the South Australian Murray Darling Basin Natural Resource Management Board, Community Grants, to continue the bat monitoring program and was trained to analyze data. Today, the Mid Murray LAP has a significant number of participants in their bat monitoring program, while still being involved with the Bats for Biodiversity program. The Mid Murray LAP has also been involved with the installation of the first permanent monitoring station at Cambrai Area School's farm Meldanda. They have also successfully secured funds to coordinate Cambrai Area Schools' bat monitoring program as well as continuing the Mid Murray bat monitoring. The future is looking very bright for the Mid Murray LAP's community bat monitoring program as it continues to expand. The plans for the future include the installation of other permanent monitoring stations throughout the region, including one at Devon Downs, where colonies of cave dwelling large-footed myotis live. A poster of South Australia's Murray Valleys bats has also been produced. The involvement of community members will continue to have a large role in the monitoring program, as the Anabats will make their way around the region. An additional focus of recording reference calls for the area will also be explored to establish a key for the region.

The conservation status of bats in Victoria

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Twenty-three species (or taxa) of bats are known from Victoria: twenty-one species of microchiroptera and two megachiroptera. Five species are listed as threatened under the Victorian *Flora and Fauna Guarantee Act* 1988 (FFG Act): Grey-headed Flying Fox, *Pteropus poliocephalus*; Yellow-bellied Sheath-tailed Bat, *Saccolaimus flaviventris*; Eastern Horseshoe Bat, *Rhinolophus megaphyllus*; Common Bent-winged Bat, *Miniopterus schreibersii*; and Eastern Long-eared Bat, *Nyctophilus timoriensis* (southeastern form). To be listed under the FFG Act, species are nominated, assessed by a Scientific Advisory Committee and approved by the responsible Minister. Threat categories are not included under the legislation. The Department of Sustainability and Environment maintains an *Advisory List of Threatened Vertebrate Fauna in Victori*a, which assesses the conservation status of species based on IUCN criteria and categories. All species listed as threatened under the FFG Act are included in the Advisory List, with the exception of the Yellow-bellied Sheath-tailed Bat, which is now considered a vagrant to Victoria. The southern subspecies of the Common Bent-winged Bat, *M. s. bassanii* is listed as Endangered, while the eastern subspecies *M. s. oceanensis* and the remaining three species are listed as Vulnerable. The Southern Myotis *Myotis macropus* is listed as Near Threatened. Extensive regional surveys throughout Victoria over the past three decades have provided a relatively comprehensive understanding of the distributional patterns of most species, although recent records continue to reveal range extensions. Ecological studies have been undertaken on some species; however, detailed data are lacking on the ecology and habitat requirements of most species. The greatest threats to bat populations are the loss and modification of their habitats. Targeted ecological research and long-term monitoring programs are required to determine population trends and to better understand threats to the continuing survival of healthy populations of bats in Victoria.

Priority Actions Statement (PAS) for threatened bats in NSW

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In 2006, the Department of Environment and Conservation New South Wales (DEC NSW) released a draft document, entitled "Introducing the Threatened Species Priorities Action Statement (PAS)." It presents a new approach to planning for threatened species recovery. The intent of the PAS is to identify the key strategies and detailed priority actions required to achieve recovery and threat abatement. Over 300 of these actions apply to threatened NSW bats of which the key strategies are habitat management, survey, monitoring and further research. These actions highlight the importance of bridging the gaps in knowledge for these species so managers can facilitate recovery on the ground. This paper presents the PAS as it has been constructed to date. We harbor no illusions that there is much to do, and that the PAS reflects a focus only on the listed bats, and not the full spectrum of species, many of which are threatened by the continuing loss of habitat, and now the added impost of climate change. The PAS is a step that will be seen as historically important because it lists actions, with some background information, hence its presentation here in full for others to comment upon, improve and act upon. For further information (http://www.nationalparks.nsw.gov.au/pdfs/pas0610.pdf accessed 5 march 2007), and more details can be seen on http://www.threatenedspecies.environment.nsw.gov.au/index.aspx accessed 5 march 2007).

Blind to bats

Dan Lunney and Chris Moon; Department of Environment and Conservation (NSW), Hurstville NSW 2220

In our experience as bat researchers over the last quarter of a century, we have been struck by the lack of coverage of bats (especially microchiropterans) in the media. The little coverage there is has primarily been periodic expressions of fear and loathing of flying foxes in local newspapers in districts where they occur. We found almost no mention of bats in the mainstream press. There is more to be found on the Internet; however, for bats, this search mechanism is haphazard and lacks quality control. We did find that bats can be a tourist attraction. Our conclusion is that the public is blind to bats, and therefore to the issues surrounding their conservation and management.

Bat research in Mumbulla State Forest since 1980

Dan Lunney, Harry Parnaby, and Peggy Eby; Department of Environment and Conservation (NSW), Hurstville NSW 2220

There has been much progress in bat biology in the last 27 years since we initiated our research into the effects of woodchipping on the bats of Mumbulla SF in 1980. Most striking has been the improvement in trapping techniques (especially the collapsible harp trap), the decrease in the weight of transmitters to about 0.5 g so that more species can now be tracked to roosts, and the invention and refinement of Anabat, especially the new Zcaim for recording only bat calls. Some powerful limitations remain for bat biologists in forests: the harp trap is largely limited to a few species; radio-tracking bats, especially with small transmitters, remains hard and slow; and Anabat, like all acoustic systems, cannot differentiate between the sexes, and cannot count individuals, only the number of sound records, and some common species cannot be separated, e.g. among the *Nyctophilus*. We also note that the ability to distinguish between species in the hand remains problematic. This is exacerbated by weak funding support for unraveling the taxonomic confusion of bat species, which in turn complicates call identification. One consequence is that any estimates of population size of any species of forest bats remain out of reach. We are also unable to define foraging habitat. Since we do not know what bats are doing as they fly through the forest, then many elements of an experimental approach to ecology are just that much harder to implement. Nevertheless, we can conclude that the research has contributed much to conserving both bats and forests, particularly the recognition of the critical importance of the old growth trees as roosts. We also regard it as important to record that the generous exchange of ideas and equipment among bat researchers has contributed greatly to our endeavors in this forest, and to bat conservation in general. This bat conference is another example of that willingness to work collectively for the common good of bat conservation.

wildlifefriendlyfencing.com

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Thousands of animals each year face a cruel death from entanglement on barbed wire. More than 60 species have been recorded, but flying foxes are affected more than any other, and entanglements are the number one reason for calls to Australian bat rescue organizations. Tolga Bat Hospital has received a Threatened Species Network grant through WWF, using the Spectacled and Grey-headed Flying Foxes as its flagship species. Entanglement is considered a threat in the Recovery Plans for these two species. Funding has also come from Bat Conservation International and RSPCA Queensland, and we are waiting to hear from several more. The wildlife-friendly fencing (WFF) project will address the issue of barbed wire entanglement as a major welfare and conservation problem in Australia, particularly for bats, gliders, raptors, and cranes. The intent of the project is to kick-start a coordinated process by wildlife groups, NRM groups, governments and others to deal strategically with the problem. The website http://www.wildlifefriendlyfencing.com is the focus for information on the project, though by mid-2007 we will have stickers, posters, and brochures. The project is raising awareness of the issue, and working with landowners when wildlife are rescued from fences. We are developing WFF guidelines and strategies, and hoping to make these a condition of any receipt of public monies for fencing. We need to gather data on the extent of the problem and various aspects of entanglement including the outcome for the animal—we have forms on the website that can be filled in for this. Watch the project develop from the website!

Using habitat modeling to better understand threatened bat species
Kylie Madden, Peter Ewin, and Daniel Connolly; Department of Environment and Conservation (NSW), Hurstville NSW 2220

Predictive modeling of preferred habitat has been used in the management of fauna for many years. However, most threatened bat species have had too little data for generating useful models; and for a number of reasons it has often been considered inappropriate for this group. Here I present some results from a recent habitat modeling project for the Greater Southern Sydney Region of New South Wales. Modeling was based on three years of intensive survey for bats and other vertebrate fauna, combined with previous survey efforts in the region. Habitat maps were effectively created for several threatened bat species. The success of the modeling project was largely due to comprehensive sampling, along with good quality predictive variables (based on high resolution vegetation mapping). The habitat maps led to interesting revelations about some of our most poorly known bat species, including the Large-eared Pied Bat (*Chalinolobus dwyeri*). Previously, this species was thought to be virtually restricted to the rugged sandstone escarpment country of eastern Australia, and was considered protected by the fact that these environments are well reserved. However, this project has shown that Large-eared Pied Bats are absent from the middle of large expanses of low-fertility sandstone woodland. Rather, they exist on the fringes where they make use of forests on higher-fertility soils and Grassy Box Woodlands. This simultaneous requirement for sandstone overhangs, where the species roosts and breeds, and higher fertility woodlands and forests for foraging may help account for why this species is so patchily distributed across its range.

Recent microbat surveys of reserves between the Hunter and the Hawkesbury including Manobalai, northern Wollemi, Yengo, and Parr
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Since 2004 the NSW DEC has been undertaking a program to address the gap in biodiversity data on large or inaccessible reserves in the northern half of the Sydney Basin. The project includes systematic fauna survey between the Hawkesbury and the Hunter Rivers, particularly within Yengo and northern Wollemi National Parks, Manobalai Nature Reserve, and Parr State Conservation Area. This presentation will summarize the results of the microbat surveys to date. Survey methods implemented are harp trapping, ultrasonic bat call detection, and searching for roost sites. Twenty-three species of microbats have been detected so far, with the composition of species differing markedly between reserves. Manobalai is characterized by species typical of the drier western slopes of NSW, such as *Nyctophilus timoriensis* and *Saccolaimus flaviventris*. Northern Wollemi supports a diverse mix of bats including species typical of both coastal and western environments. For example, *Scotorepens orion* and *Mormopterus norfolkensis* are present in conjunction with *Scotorepens balstoni* and *Mormopterus* species 3 (short penis form). The higher altitude environments in Central Wollemi have resulted in the greatest number of *Vespadelus darlingtoni* and *Falsistrellus tasmaniensis* captures. Surveys of southern Yengo and

Parr are not yet complete, but so far have detected a relatively small number of bat species, dominated by species typical of sandstone coastal hinterlands. The surveys have detected numerous new locations for threatened species, one highlight being the discovery of a maternity roost of *Vespadelus troughtoni*. The data generated by the surveys are informing reserve and threatened species management. In the future the data will be used for habitat modeling and identification of conservation priorities, building on the work recently undertaken by DEC for southern Sydney.

Is the fat lady singing? Contemplations on the amendment of an environment act
Nicola Markus

Environmental legislation is fundamentally important. It determines conservation priorities, keeps a tally of how threatened species, ecological communities and conservation efforts are tracking, sets the frameworks by which conservation happens, regulates activities that impact on the environment, and it gives direction to the funding schemes that fund conservation efforts. The federal Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) was hailed as a progressive and potentially powerful piece of legislation when it first commenced in July 2000. In December 2006, a suite of amendments to the Act were passed that have broad implications for the conservation of all threatened species, flying foxes and microbats among them.

Investigation of the success of artificial roosts for *Myotis macropus* at Koala Beach NSW
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In 1997 compensatory roost sites for the microchiropteran bat species, *Myotis macropus* were incorporated into the bridge design for a new concrete bridge on the Tweed Coast of NSW. This arose as a result of recommendations from the Fauna Impact Statement (FIS) and requirements for a National Parks and Wildlife Service (NPWS) section 120 License as part of the development application approval. *Myotis macropus* is a vulnerable species listed on Schedule 2 of the Threatened Species Conservation Act, 1995. *M. macropus* seldom occur far from suitable water bodies. Roosts include caves, mines, tunnels, under bridges and buildings, and in dense foliage in tropical areas. They tend to inhabit disturbed or human-constructed sites that are likely to deteriorate—hence the need to consider their habitat requirements when constructing new infrastructure. Lack of detailed data on the specific roost configurations and roost microclimate for *M. macropus* meant that a diversity of roost types had to be used to maximize the potential utility of the artificial roosts. Twenty-nine artificial roots using four distinct designs were constructed and attached at various angles and positions beneath the concrete bridge. The artificial roosts were located to minimize human access, and orientation was varied to cover diverse roost environment, thus creating a greater chance of occupation by bats. The range of positions for each roost design varied according to orientation to stream flow, distance from edge (as opposed to end) of bridge, and north verses southern edge in relation to possible differences in shading and sun exposure. Few studies have investigated the effectiveness of artificial roosts over extended time periods. Such research provides valuable information on the success of the compensatory measures employed and their significance in the conservation of fauna species (particularly *M. macropus* in this instance) and viability for future projects. Compensatory habitat and fauna mitigation measures are increasingly becoming an integral part of development, particularly in coastal regions such as the Tweed Shire, which have such uniquely high biodiversity. The artificial boxes have been monitored since 1997. Ten years after the new bridge was built, the boxes erected provide conclusive evidence that given the right micro- and macro-conditions, artificial boxes can be successfully incorporated into new bridge design and provide artificial habitat for threatened bat species.

Is the fruit you eat flying-fox friendly? The effects of orchard electrocution grids on Australian flying foxes (*Pteropus* spp., Megachiroptera)

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Orchardists have used electrified grids, which kill or injure flying foxes, to "protect" fruit crops. A 2001 Federal Court judgment prohibited use of one 6.4 km grid because it adversely affected World Heritage values. Subsequently, Queensland stopped permitting grid operation—an orchardist's appeal against this was withdrawn before going to court. Two NSW orchardists using a grid, pleaded guilty to cruelty/aggravated cruelty. Orchardists' responses to these cases, and difficulties in policing grids—many of which remain in working order in Queensland—stimulated this review. It summarizes evidence that grids: are ineffective in preventing damage to crops; do not selectively kill flying fox "scouts"; will significantly hasten decline of flying fox populations; do not kill flying foxes "instantly" but inflict extreme pain and suffering *before* death; injure some animals, which survive in severe pain, and cause pain/ suffering to suckling young via death of mothers. Apropos the *NSW Prevention of Cruelty to Animals Act*, grids cause (1) *multiple uncontrolled acts of cruelty*: <u>multiple</u> in that many bats are affected, <u>uncontrolled</u> in that there is no control on the numbers of bats affected, <u>acts of cruelty</u> in that animals are unreasonably and unjustifiably mutilated, maimed, terrified, exposed to excessive (electrical) heat and inflicted with pain; (2) *multiple uncontrolled acts of aggravated cruelty*, in causing death or serious disablement of <u>multiple animals</u>, some being so severely injured that it is cruel to leave them alive. Since exclusion netting is a wholly effective, non-lethal means of protecting crops, electrocution grid operations should be prohibited.

Grey-headed Flying Foxes in orchards: a collaborative project on damage estimates, contributing factors, and mitigation strategies—triumphs and tribulations of flying fox conservation and management in NSW

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The Grey-headed Flying Fox, *Pteropus poliocephalus*, (GHFF) is listed as a threatened species in NSW, Victoria, and nationally. The GHFF is a key species in maintaining forest ecosystems through the pollination of native trees and the dispersal of rainforest seeds. This threatened species is unique in that it is also recognized as a horticultural pest, predominantly in coastal orchards of southeastern Australia. In times of native resource (pollen, nectar and rainforest fruits) shortage, flying foxes are known to utilize commercial fruit crops. As such, the species is affected by control techniques employed by horticulturists to mitigate flying fox damage, including shooting and netting. The NSW Department of Environment and Conservation (DEC) and the NSW Department of Primary Industries–Agriculture (DPI) are working collaboratively to investigate flying fox damage to commercial crops to assess/quantify the levels of flying fox damage (temporally and spatially), to determine the factors contributing to trends in crop damage, and to assess the effectiveness of mitigative measures employed by horticulturists to reduce flying fox damage. The project is funded for two financial years through the Australian Government's Natural Heritage Trust Strategic Reserve funding and State Government contributions (cash and in-kind), and addresses several recovery actions of the draft National Recovery Plan for the GHFF (in preparation). The project proposal was also strongly supported by the NSW Flying Fox Consultative Committee. The project commenced in October 2006 and focuses on commercial crops in the western Sydney Basin. To date, preliminary trials have been conducted in the Bilpin, Kurrajong and Darkes Forest areas. Parameters currently under investigation include total yield loss, damaged fruit (including that specifically attributable to flying foxes), flying fox crop visitation indices, and crop architecture. These parameters will be compared across different stone fruit and apple crop types, and between netted and un-netted crops to examine spatial and temporal trends. The process of establishing and implementing the collaborative project is discussed, within the framework of flying fox conservation and management in NSW.

The novel reproductive biology of the female flying fox and its implications for the successful development of artificial insemination

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Artificial insemination (AI) has the potential to play a primary role in the conservation of endangered flying foxes, through the genetic and reproductive management of captive colonies. Semen from surviving wild populations, or from separate captive colonies, can be utilized to maintain genetic vigor, thus preventing in-breeding in potential seed populations that can then be returned to restored habitat. The development of AI technology in flying foxes has been hampered by the atypical reproductive biology of female megachiropterans. Pteropodids have a duplex uterus, with separate cervices, and a well-defined ovarian vascular complex that provides a counter-current exchange system between the ovary and ipsilateral uterine horn. This arrangement reduces systemic circulation of steroid reproductive hormones and makes it difficult to accurately characterize the endocrinology of the estrous cycle; it is also consistent with the apparent lack of overt behavioral estrus in these species. Low concentrations of peripheral estradiol also mean that vaginal cytology is not a strong correlate of reproductive status. If AI is to be utilized as a conservation strategy in flying foxes, it is vital that an accurate method of estrus detection be established. The integrated examination of plasma hormones, behavior, and vaginal cytology, following direct hormonal stimulation of folliculogenesis in the ovaries, may improve the signal to noise ratio in this subtle physiological system. Such improved sensitivity may make it possible to develop an accurate method of estrus detection. Development of the remaining steps in AI may then proceed.

Smile and the world smiles with you or complain and get more attention!

Tristan Moylan; jolea@ceinternet.com.au

Grey-headed Flying Foxes are an important part of our environment. However, society has complained and deemed the bats as problems and pests, portraying them in a negative light.

There is a need for this important and threatened species to be portrayed in a positive way. I am currently studying Design and Technology as part of my HSC, I have chosen to base my Major Design Project on the positive portrayal of Grey-headed Flying Foxes. I have created a promotional cartoon character that can be appealing to a wide variety of audiences, as I would like the world to smile with me. My poster design incorporates my Grey-headed Fruit Bat character as part of a comic strip. The comic strip acknowledges the issue of the fruit bat's habitat being destroyed by humans and their migration into urban society.

Alimentary canal is optimized for the flight and inverse posture of *Pteropus scapulatus*, the Little Red Flying Fox (Megachiroptera)

Gemma M. O'Brien; University of New England, NSW 2351

Flying-fox biology is remarkable in many respects, including how quickly ingesta become excreta, how wet and unformed that excreta are, and how the gut motility between ingestion and excretion proceeds against gravity. Special stomach morphology observed in *Pteropus scapulatus*, the Little Red Flying Fox (suborder Megachiroptera), probably helps to localize heavy gut contents close to the animal's centre of gravity. The anchoring of the rectum parallel to the spine also appears ergonomically favorable for flight. Processing in the mouth greatly reduces the time food needs to be retained in the stomach. The morphological arrangement of the ileo-colic junction implies a functional ileo-colic valve mechanism even if it is not structurally well defined. Overall, the digestive tract of *P. scapulatus* is well suited to ingesta that arrive in semi-liquid form, in pulsed feeding bouts, to digesta that are processed rapidly, and to excreta that remove excess water with the waste digesta. Form and function are optimized.

Genomic and epigenetic regulation of flying fox reproduction

Gemma M. O'Brien; University of New England NSW 2351

Timing of seasonal reproduction by flying foxes is apparently dependent on an endogenous circannual rhythm, coded in their genome. Ultimately, evolution of an endogenous rhythm aligns an important reproductive stage, such as lactation, with resource availability such as the occurrence of maximum plant productivity; animals then do not have to rely on proximate factors to predict conditions nine months in advance. External influences that re-align reproduction to match a phase-shift in environmental conditions have to either adjust the period of the biological clock, or else induce a phase-shift, to bring breeding back into line with prevailing conditions. These are epigenetic factors: they influence the expression of genes without altering the DNA. Stages of reproduction relate temporally with the endogenous rhythm, but individual flying foxes may need to make fine adjustments in their own timing. To do this they probably monitor a suite of environmental conditions. It has been proposed that if a signal changed in isolation from other factors it would be ignored. For example, it is important that a nomadic species be not directly responsive to photoperiod since this differs when they move between latitudes. A reproductive stage would, however, be inhibited if several cues warned against proceeding, e.g. inadequate forage combined with long commuting distances at a time of unfavorable temperatures. What epigenetic factors regulate flying fox reproduction? It is likely that rainfall is part of the regulation for the overall rhythm, while current energy balance is probably important for individual animals during many stages of their reproduction.

Defining conservation issues for hollow-using bats in inland ironbark and mixed species eucalypt forests: an example from the Pilliga forests of NSW

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Current threats to bat species in the Pilliga include (1) loss of tree hollows, and future recruit trees for hollow formation; (2) climatically induced changes to fire regimes; (3) perceptions of tree longevity and confusion about the pre-European condition of Pilliga forests; (4) the imperatives of extractive industries; and (5) lack of baseline research. Past removal of the majority of the hollow resource from forestry activities and fire has resulted in tree age classes that are highly skewed toward very young or very old trees over most of the forest estate. Without management intervention, a critical shortage of hollows is anticipated until at least 2300 AD, based on estimates of tree longevity and lead times for hollow formation for slow growing inland hardwoods. Given this, restorative management actions have considerable merit. It is concluded that all species of hollow-using bats could face impending population declines and many species could face regional extinctions in the coming decades. Management issues and threats to hollow-using bat species in the Pilliga forests are common to similar forests that extend from southeast Queensland to Victoria.

“Diverse Weights and Diverse Measures” glitches in ageing juvenile Grey-headed Flying Foxes (*Pteropus poliocephalus*)

Kerryn Parry-Jones; University of Sydney, NSW 2000

Grey-headed Flying Foxes, *Pteropus poliocephalus* are considered Vulnerable under both State and Federal legislation. However, very little is known about the life history of this animal in the wild, and central to determining the population dynamics of *P. poliocephalus* is the need to age wild animals accurately. Traditionally, juvenile *P. poliocephalus* are aged by comparing their forearm measurements and weights, to scales based on the growth rates of known-aged captive animals. In this paper, the reliability of this method is assessed by investigating 10 years of data collected by the Wildlife Animal Rescue and Care Society, a rehabilitation organization in NSW. These data consist of weekly weights and forearm measurements for both orphan flying foxes that had been hand-reared and mother-reared animals that had been born to captive flying foxes over periods in which the diet varied for both adults and hand-reared juveniles. Forearm size is a more reliable indicator of age than weight. However, the growth of the forearm is not uniform from animal to animal as both inheritance and diet cause variations in the rate of growth. Neither forearm length nor weight gives an accurate assessment of the age of a juvenile *P. poliocephalus* and other methods of ageing should be investigated.

Practical solutions for catching and processing Grey-headed Flying Foxes, *Pteropus poliocephalus* based on a population study at the Royal Botanic Gardens, Sydney

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Grey-headed Flying Foxes, *Pteropus poliocephalus* can be difficult to catch in sufficient numbers for population studies and large numbers of *P. poliocephalus* have not been

anesthetized under field conditions. We describe methods that have proven successful and evaluate their practicality. Over the last year (23 catching nights) we caught (and banded with ABBBS bands) 390 Grey-headed Flying Foxes from the Royal Botanic Gardens' colony. Between 8 and 53 bats were caught per catching night as they returned to the roost site in the early morning, depending on weather conditions and net orientation. Animals were captured using a standard 12 m long mist net on pulleys attached to two 13 m tall stainless steel poles, each of which is assembled from six smaller poles. The poles are relatively light but require four people for safe net assembly. Detailed information was obtained from 287 individuals that were processed; the juveniles were banded and released. We anesthetized each individual and recorded standard morphometric measurements. Pollen and fecal samples, as well as tissue samples, including blood, membrane puncture, and a tooth were also collected. Six animals were additionally fitted with radio-collars. The processing generally lasted under 10 minutes/animal and bats recovered from the anesthetic within an hour. When fully alert, each bat was released back into the colony by flying it across a lawn to the roost trees. No casualties have resulted from catching or processing the flying foxes and no processed animal has subsequently been found ill or dead as a result of this project.

A preliminary analysis of aircraft bat strikes in Australia
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Collision with bats is often considered to represent a significant threat to commercial and military aircraft in Australia, even though specific studies designed to quantify and mitigate these effects have yet to be implemented. Here we report on the first statistical analysis of bat strike records within Australia. Using the Australian Transport Safety Bureau database (which includes records of bat strikes) in combination with the Air Services Australia database (which reports records of movements of aircraft within Australia), we summarize the incidence of bat strikes in Australia, relative to aircraft activity. Preliminary results indicate that time of night (evening vs. early morning) and airport location significantly influence the probability of bat strikes in Australia.

Aerial photography and digital image analysis: new techniques for monitoring problematic flying fox camps
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Monitoring flying fox populations and their seasonal variations can be challenging, particularly in regional and remote camps that are located in difficult and dangerous terrain (due to impenetrable mangrove thickets, thick mud, and the presence of estuarine crocodiles). Here we evaluate the utility of aerial photography and image analysis techniques, to monitor camps of *Pteropus alecto* and *P. scapulatus* in the Townsville region. Image analysis software such as Image Tool and Adobe Photoshop provide a rapid and repeatable method of identifying and counting individual flying foxes in photographs. This technique provides a safe, relatively rapid and non-invasive method for monitoring flying fox camps, and is particularly suitable for the study of camps that are remote and/or difficult to access.

Review of the distribution and status of New South Wales and the Australian Capital Territory bat fauna

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New South Wales (NSW) including the small enclave of the Australian Capital Territory (ACT) has a diverse bat fauna of 39 taxa (34 microchiropterans and 5 megachiropterans). In NSW 22 (56%) of chiropteran taxa are listed as threatened, 20 as vulnerable, 1 as endangered, and 1 extinct under the *Threatened Species Conservation Act 1995*. This reflects the recognition of the threatened status of most NSW bats under the first threatened species legislation in NSW, the *Endangered Species (Interim Protection) Act 1991*. There are no threatened bats listed in the ACT under the *Nature Conservation Act 1980*. The main reasons for listing of NSW threatened bats were reduced population or distribution, ecological specialization, concentrated populations, and habitat loss. We mapped the geographic distribution and relative density of observations for each species using weighted Kernel Density Estimate models based on 92,000 unique records of more than 3 million individual bats observed in NSW and ACT. Distribution and observation data were used to investigate trends in reporting rates for each taxon over the past decade using a nonparametric rank analysis to determine the annual ratio of observations per species versus a surrogate for effort. We also investigated regional patterns in the distribution of the bat fauna using PATN association and classification analysis to identify 6 distinct 'bat regions' based on the species composition of the 18 biogeographic regions within NSW and ACT. We found that survey effort and data were unevenly distributed spatially, taxonomically and temporally. Fifty-six percent of all records are from three coastal bioregions, five species account for 52% of all records, and conversely over 50% of the species account for less than 5% of all records. Further, most (60%) of all records are from the last 10 years. As most of our data have been collected by large-scale inventory type surveys, we recommend that greater attention should be devoted to targeted research and increased long term monitoring. Without monitoring, identifying trends in species and populations is almost impossible. The status of most bats will remain threatened without action to ameliorate threats and monitor changes in population and distribution.

Determination of the minimum bat sample group size to provide reliable parasite indices

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Characterization of a whole population based on sample groups will always have a representation error, which will change with growth of the sample group size. At a certain point it will be negligible and with further examinations beyond that point the error remains practically unchanged. A graphic method is proposed to identify that point, determining the minimum size of the bat sample group needed to provide reliable parasite indices. Calculations with various numbers of microbat hosts and subsequent visualizations have shown that to obtain a reliable Abundance Index of bat fleas (Siphonaptera, Ischnopsyllidae) or bat flies (Diptera, Nycteribiidae) in winter-spring season, only 35–40 bats should be examined. In summer, with many young animals in populations, the number of examinations should be increased up to 50–55. Similar results are obtained for the Infestation Index. Examination of only the necessary number of hosts allows minimization of disturbance and stress levels to animals, as well as time and amount of fieldwork, without negative impact on the data reliability. This is especially

important while dealing with rare and endangered species, as the biological value of each animal and each specimen is incomparably higher.

Use of dogs in bat surveys
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Searching for bats and their roosts in the wild is often a challenging task, as bats are secretive and in many cases undetectable animals. Extraordinary olfaction capabilities of dogs make them the best natural tool for various wildlife surveys, including those for bats. Our use of dogs in bat surveys in 1980s–1990s shows that they are capable of finding bats' excrements and roosts on the surface, underground (caves and mines), and inside man-made structures with a great of accuracy under the range of environmental conditions. Basic requirements for a bat detection dog are: the dog must find the target, indicate its find, and do it without disturbing or harming target animals, handler, and itself. A reward-based training method has been used to develop a reliable trained alert. Body language (posture, tail or ear-set movement, facial expression, etc.) is an alternative way to recognize encounters with a target smell. Dogs are able to generalize and can be trained on bats, their excrements or residual scent and then can effectively locate the source of smell they had never previously encountered. Use of dogs significantly improves field data collection, offering a risk-free, non-invasive field technique to cover larger areas faster and more accurately.

Conservation status of the bats of South Australia
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Twenty-seven bat species have been recorded in South Australia. The National Parks and Wildlife Act 1972 recognizes three categories of threatened status, namely Endangered, Vulnerable and Rare. The criteria for listing under these categories have recently changed, and are now based on IUCN criteria. In the latest review currently before cabinet, twelve bat species fall into one or other of these categories. There is a move in the State to scrap these old categories and adopt the IUCN categories. Gaps in our knowledge of South Australian bats will also be discussed.

Ecological separation of two *Mormopterus* species in sympatry
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Resource partitioning enables closely-related, morphologically similar species to coexist. This study investigated resource partitioning by two closely-related insectivorous bat species, the Eastern Free-tailed Bat *Mormopterus* sp. 2 and Southern Free-tailed Bat *Mormopterus* sp. 4, within their sympatric zone in northern Victoria. Thirty-six sites were sampled using harp traps and bat detectors. A total of 159 *Mormopterus* was caught, and 961 identified echolocation passes recorded. Analysis of wing dimensions suggested that *Mormopterus* sp. 4 was a faster, less maneuverable flyer, which was supported by greater levels of activity in sites that were more open and less structurally complex. *Mormopterus* sp. 2 showed greater levels of activity in riparian habitats, which may be due to a preference for more mesic environments. Observations of flight patterns revealed slight differences in the two species' microhabitat use, with both species predominantly flying in the spaces between trees. Fecal pellet analysis found that Hemiptera was the most consumed arthropod order of both species. The subtle, yet significant differences in wing morphology were reflected in the slight differences in microhabitat use by the two species, and the presence of superabundant hemipteran prey may have allowed the two species to overlap their trophic niches.

Bats and wind farms: a review of issues and techniques to progress the development of formal assessment guidelines

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Because of the controversial nature of wind farm projects and their potential impact upon threatened bat populations, bat fauna assessments at proposed sites need to involve rigorous study and there is much need for formal guidelines. This paper outlines the pitfalls, problems, and practicalities experienced by the author at ten of these important developments in NSW, and four in Victoria. The paper provides information on pre-approval survey methods, post-construction monitoring strategies, and reviews recent consent conditions for a wind farm that are likely to set current standards for NSW. Topics covered include habitat selection patterns at wind farm sites, activity patterns in relation to weather and climate, effect of wind speed on foraging activity, activity in the rotor swept area, methods for targeting migratory species, and our current knowledge of patterns of avoidance and collision. It was concluded that if precise and meticulous studies are conducted, and a series of protocols are developed to address threatened species issues, then wind farms are valuable developments that can help arrest the impact of climate change upon bat populations in general.

Human–Flying Fox conflicts: are relocations the answer?

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Managing flying fox camps has become an increasing challenge for agencies responsible for managing wildlife, and for communities along the east coast of Australia. Conflict arises between humans and flying foxes as a result of flying fox campsites being located adjacent to, or within, urban and peri-urban areas. In many cases, members of the public immediately propose that the camp should be relocated. This poster examines the consequences of attempts to relocate the flying fox camp at Maclean, northern NSW. In 1999, a coordinated disturbance commenced aimed at ensuring flying foxes did not roost adjacent the school in the township of Maclean. This camp was a regularly used, maternity site that had been occupied by flying foxes for over 100 years. Since the disturbance there have been over 20 attempts by flying foxes to re-establish the Maclean campsite. Initially the disturbance fragmented the colony throughout the town and flying foxes made regular attempts to return to their traditional site. The number of attempts has since progressively declined, but flying foxes are still returning to the site six and a half years after the initial relocation (last attempt October 2005). The total cost of the relocation is at least $750,000 and is ongoing; this includes about 600 person-hours. Since the initial disturbance at least thirteen alternative sites have been used by flying foxes across the district. Twelve have been used temporarily and irregularly. In addition, in 2004 a continuously occupied camp was established in the Iluka township. It is highly probable that the flying foxes from Maclean have relocated to Iluka. Residents of Iluka now wish to relocate this flying fox colony. The experience at Maclean raises the question of how the success of relocations should be defined, and at what spatial scale success should be assessed.

Bats—where to from here?

Martin Schulz; Department of Environment and Conservation (NSW), Hurstville NSW 2220

Bat conservation and bat research are constantly limited by lack of funds. This paper will present some approaches aimed at improving this situation and will then invite discussion from the audience.

Large-scale redistribution of Spectacled Flying Foxes (*Pteropus conspicillatus*) after Tropical Cyclone Larry

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Wildlife responses to major habitat disturbance have rarely been examined at large spatial scales, and available information on flying fox (*Pteropus* spp.) behavior following cyclonic events is limited to small oceanic islands. Tropical Cyclone Larry, which hit Far North Queensland in March 2006, provided a unique opportunity to examine the impacts of such an event on *Pteropus conspicillatus* population distribution across the Wet Tropics bioregion, as we had collected data over two years pre-cyclone. Here we report on how *P. conspicillatus* re-distributed immediately after the cyclone, and over the subsequent 12 months. Post-cyclone, *P. conspicillatus* were typically found in only small camps until December 2006, nine months after the cyclone, and in certain months during this period up to 90 percent of the pre-cyclone *P. conspicillatus* population (c. 250,000) was unaccounted for at known campsites. Calls for public information on flying fox whereabouts assisted us in locating small camps of *P. conspicillatus* at eight 'new' locations, but added little to the overall population estimate. At the time of submission, the *P. conspicillatus* population appeared to be around 150,000—60 percent of the pre-cyclone estimate. Short- and long-term cyclonic impacts on the *P. conspicillatus* population in Wet Tropics bioregion will be discussed in relation to implications for future conservation and management of this threatened species. Only ongoing data collection will reveal whether the population has declined as a result of the cyclone, or whether the unaccounted population is roosting at yet to be discovered locations.

Microclimate preferences of Grey-headed Flying Foxes

Stephanie Snoyman; Macquarie University, NSW 2109

The Grey-headed Flying Fox (GHFF) (*Pteropus poliocephalus*) is a highly social species, spending much of its time in roosting camps that comprise tens of thousands of individuals. Currently campsite selection of GHFF is an enigma, and although there have been a number of studies attempting to identify camp characteristics, it is not understood why certain locations are favored over others. Given the lack of knowledge on this topic, I have initiated a study aimed at determining the microclimate preferences of roosting GHFF in five camps in greater Sydney. At each camp I will record microclimate variables (wind speed, temperature, humidity, solar irradiation) at ten locations within occupied trees and contrast them with ten similar locations around the camp perimeter using remote sensors and data loggers. Behavioral observations of the GHFFs will occur in concert with the logging of environmental data to determine how GHFFs cope with varying climatic challenges. The results of the study have the potential to feed directly into management of flying fox camps not just within suburban Sydney but also throughout the species distribution.

Remotely interrogatable collar-mounted GPS logger for flying foxes
Hugh Spencer and Tim Miller; Cape Tribulation Tropical Research Station, Australian Tropical Research Foundation, Cape Tribulation QLD 4973

Flying foxes, *Pteropus* spp. are highly mobile animals, ranging over distances often exceeding 100 km each night merely to feed, and far greater movements during times of colony shifts. Accurately monitoring movements over such distances is completely out of the scope of conventional radio-tracking technology. ARGOS satellite transponders are useful for tracking long range (inter-continental) movements but the locational accuracy tends to be very poor, about 1 km. To overcome these deficiencies and to allow us to track animals with accuracies of better than 3 meters, we have developed a solar-powered GPS-based logger, small enough (60 gm) to be carried by an adult flying fox. This logger (60,000 locations) permits us to monitor flying fox feeding behavior, energetics, and even shifts in forest phenology with changing climate, as we can visit and identify individual feeding trees. With a down-load range of up to 0.5 km, we are able to remotely download the data without actually having to capture the animal or wait for the collar to fall off. Each collar has an integral conventional radio-tracking beacon to permit us to locate the animal for download. Data from the loggers are plotted on a GIS topographical and vegetation map database. We are hoping to deploy 50 units on *Pteropus conspicillatus* over the next couple of years, together with volunteers based in the field who can access known colony sites to download the data. From this we should be able to develop a far more accurate understanding of the dynamics of flying fox behavior, especially seasonal shifts and the distribution of food resources in the region, an understanding which should be able to provide us with predictive tools for minimizing crop damage and monitoring changes due to global warming.

Monitoring of a maternity colony of White-striped Free-tailed Bats (*Tadarida australis*)
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A known maternity colony of White-striped Free-tailed Bats (*Tadarida australis*) within a building was monitored with video recording and Anabat call recording over a period of four months (Dec 05–March 06). The presence of a maternity colony of this species in a building is of high significance, as roosting in buildings has not been previously recorded for this species, and known locations of maternity colonies of this species within Sydney are limited. Monitoring was able to assess the initial size of the maternity colony in the building and the increase in population numbers from 26 to 44 individuals over the breeding season, an increase of ≥18 individuals. A few photographs of young bats present in the roost were also taken. Additionally unusual vocalization behavior for this species was recorded. This call variation has previously been noted by Monika Rhodes. The variations in calls included a ‘melodic’ undulating type call and a steep, high frequency FM call. These call variations are yet to be described in detail, and the role of these calls is still to be determined, but some at least are considered likely to be social calls. Monitoring of this colony is ongoing, and further techniques will be utilized to gain a better understanding of the behavior of this species. An update on findings from recent monitoring will also be presented.

The movements of Large Bent-winged Bats *Miniopterus schreibersii* between sites in the eastern suburbs of Sydney

Arthur W. White; Biosphere Environmental Consultants, Rockdale NSW 2216

Large Bent-winged Bats have been recorded roosting in a variety of man-made structures in Sydney. These structures include disused buildings, railway tunnels, storm water culverts, and military installations. The bats roost in these sites during the summer months and desert the sites in winter, only to return the following spring. In 2003, a new roosting site was discovered at Malabar in Sydney's eastern suburbs. This site was close to another known roosting site at La Perouse (Henry Head). Monitoring results over the next two and a half years found that the bats moved between these two sites in response to wind strength and humidity. The bats moved away from the more exposed sites (at Cape Banks and Henry Head) during windy weather and sheltered in the less exposed roosting site at Malabar. After heavy rain, the Malabar site became partially flooded and the humidity in the roost remained high for four months; during this period the bats avoided this roost even though it was the most protected site during strong winds. Roost site air temperature did not appear to be causative factor in roost site selection.

Design components for a bat flyway through Sydney

Arthur W. White; Biosphere Environmental Consultants, Rockdale, NSW 2216

Microbats are often limited in their flight paths in urban areas. Street lighting, noise, wind exposure, and inadequate tree cover often prevent smaller bats from moving between potential feeding areas. In 2004 and 2005, a bat survey of the Willoughby Local Government Area (LGA) was carried out on a street-by-street basis. From these data, regular bat movements were recorded and existing major bat flyways determined. In general, two major flyways were present in the Willoughby LGA—the first was along the Lane Cove River Corridor in the western section of the LGA, the other was along the Middle Harbour foreshore in the eastern section of the LGA. Small microbats did not seem able to cross the Pacific Highway rise to move between these major flyways. The Willoughby LGA was then surveyed on foot to determine if a microbat flyway could be constructed across the LGA from east to west, linking the two major flyways. To do this, the flyway would have to cross urban areas, the northern rail corridor and the Pacific Highway commercial district. A potential flyway was chosen on the basis of the existing and potential street tree cover. The rail and highway crossing would entail the construction of a darkened, wind-shielded overpass; the access and departure points for the overpass would also be darkened and surrounding street lighting altered to make the overpass more conducive to bat movements.

List of Attendees

Royal Zoological Society of New South Wales and Australasian Bat Society Symposium on the Biology and Conservation of Australasian Bats

Sydney NSW Australia, 12–14 April 2007

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RECENT LITERATURE

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ANNOUNCEMENT

Call for Papers—Special Volume of *Chiroptera Neotropical*

Dear Researchers,

During the I South American Congress on Mammalogy (October 2006), the Brazilian Society for the Study of Chiroptera (SBEQ) was created, and meetings between researchers from all over Brazil led us to organize a special volume of *Chiroptera Neotropical* dedicated to the Caatinga biome.

In order to strengthen the role of *Chiroptera Neotropical* as major channel for scientific publication and forum of communication for biologists dedicated to the study of Neotropical bats, and as part of commemorations on the tenth anniversary of the journal, the editors and organizers of this special volume invite potential authors to submit their contributions on Caatinga bats to this volume. Original contributions may focus in any aspect of the biology and conservation of Caatinga bats.

For those who are interested in submitting articles to this special volume of *Chiroptera Neotropical,* please contact the organizers of this volume. Manuscripts must be submitted according to the journal's instruction for authors found in the last pages of the journal or in the journal's website < **http://chiroptera.conservacao.org/index.htm** >

We hope to have your help in spreading the news of this call for papers to other researchers working on Caatinga bats in order to improve and ensure the success of this project.

Sincerely yours,
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FUTURE MEETINGS and EVENTS

July 29–August 2, 2007
The Cherokee National Forest will host the annual SBDN bat blitz near Roan Mountain/Johnson City, in the Southern Blue Ridge Mountains of northeastern Tennessee. Contact Laura Lewis [**lauralewis@fs.fed.us** or telephone (423) 476-9752] or see **http://www.sbdn.org** for information.

August 19–23, 2007
The 14th International Bat Conference and the 37th Annual NASBR will be held in Mérida, Yucatan, Mexico, 19–23 August 2007. For more information, please check the website at: **http://batconference.confhost.net/**.

October 17–20, 2007
A symposium entitled "Fossils, Molecules and Morphology—Evolutionary History of Bats" will be held during the 67th Annual Society of Vertebrate Paleontology (SVP) Meeting in Austin, Texas. The symposium will focus on morphological and molecular methods as they apply to studying the evolution of bats, and will include presentations by bat specialists from Europe, Australia, South America, and North America. For more information about the symposium and the SVP meetings, please check the website at: **http://www.vertpaleo.org/symposia_topics.htm**

August 31–September 2, 2007
The National Bat Conference will be held at University of York, United Kingdom. For more information please contact **MFray@bats.org.uk**

August 2008
XIth European Bat Research Symposium will be held in Cluj-Napoca, Romania. For more information, please contact: **farkas@xnet.ro**

October 22–25, 2008
The 38th annual NASBR will be held in Scranton, Pennsylvania.

November 4–7, 2009
The 39th Annual NASBR will be held in Portland, Oregon.

August 2011
XIIth European Bat Research Symposium will be held in Lithuania.

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Front Cover

The cover photograph of the Grey-headed Flying Fox, *Pteropus poliocephalus*, was kindly provided by Vivien Jones (http://www.bellingen.com/flyingfoxes), and was used as the logo for the 2007 Royal Zoological Society of New South Wales and Australasian Bat Society Symposium on the Biology and Conservation of Australasian Bats. Copyright Vivien Jones (reproduced with permission from the artist).

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Bat Research News is published four times each year, consisting of one volume of four issues. *Bat Research News* publishes short feature articles and general interest notes that are reviewed by at least two scholars in that field. *Bat Research News* also includes abstracts of presentations at bat conferences around the world, letters to the editors, news submitted by our readers, notices and requests, and announcements of future bat conferences worldwide. In addition, *Bat Research News* provides a listing of recent bat-related articles that were published in English. *Bat Research News* is abstracted in several databases (e.g., BIOSIS).

Communications concerning feature articles and "Letters to the Editor" should be addressed to Al Kurta, conservation items to Pat Morton, and all other correspondence including recent literature items to Margaret Griffiths. (Contact information is listed above.)

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Abstracts of Papers Presented at the

First International Southeast Asian Bat Conference

Phuket, Thailand
7–10 May 2007

The following abstracts are from papers presented at the First International Southeast Asian Bat Conference. Given the complexities of the names and the inconsistencies across multiple countries regarding the order of presenting given names and surnames, the abstracts are listed in the same order as that of the papers presented at the Conference. Abstracts were compiled, edited, and submitted by Tigga Kingston. During preparation of the abstracts for publication, editorial and formatting changes were made to the abstracts by the Editor of *Bat Research News*, Margaret Griffiths. Any errors that may have been introduced during this preparation are inadvertent, and she asks that you please accept her sincerest apologies.

Many thanks to the organizers of the Symposium—Chutamas Satasook, Tigga Kingston, and Paul Bates—for granting *Bat Research News* permission to publish the abstracts. Contact information for authors who attended the Conference can be found in the list of meeting participants, which immediately follows the abstracts.

Bat Conservation in Southeast Asia: Research, Capacity Building and Outreach in a Critical Region

Tigga Kingston[1] and Zubaid Akbar[2]; [1]Department of Biological Sciences, Texas Tech University, Lubbock, TX 79409-3131, USA; [2]Faculty of Science and Technology, Universiti Kebangsaan Malaysia, Bangi 43600 UKM, Malaysia

Bats are a highly diverse component of vertebrate diversity in the rainforests of Southeast Asia, yet by the end of this century as many as 20% of the region's bat fauna are predicted to be globally extinct. Nowhere is this biodiversity crisis more evident than in Peninsular Malaysia, a critical country for international bat conservation, with over 100 known species of which more than a third are IUCN red-listed. Local species richness can exceed 50 species, and many species are tied by ecomorphological specializations to intact stands of forest. The Malaysian Bat Conservation Research Unit (MBCRU) was established in 2001 to promote research and conservation education of this unique fauna. It is a collaboration between scientists and educators from the USA, Malaysia, and the UK. The primary objectives of the unit are: long-term research on bat diversity and conservation, capacity building, and education and outreach. We present the activities of the MBCRU's first five years with particular emphasis on our efforts to develop a predictive framework to determine local extinction risk in diverse, intact systems. Finally, we detail the launch in 2007 of a regional initiative—the Southeast Asian Bat Conservation Research Unit (SEABCRU). Modeled on the MBCRU, the SEABCRU will identify regional priorities for bat conservation, develop and implement research protocols and unite capacity building and outreach programs across Southeast Asia.

Bat Research and Conservation in China: Recent Developments under the Darwin Initiative

Gareth Jones[1] and Shiyu Zhang[2]; [1]School of Biological Sciences, University of Bristol, Bristol BS8 1UG, UK; [2]Institute of Zoology, Chinese Academy of Sciences, Haidian, Beijing 100080, China

The authors have been researching bat ecology and biodiversity in China since 2001. Our recent work has been funded by a Darwin Initiative grant. We present an overview of our findings, which includes results on dietary ecology (e.g., piscivory in *M. ricketti*; bird-eating by *Ia io*), phylogenetics (e.g., phylogenetic diagnosis of *Myotis pequinius*, taxonomic status of *Rhinolophus pusillus*) and autecology (e.g., studies on *Tylonycteris* species). We have established a centre for bat research near Beijing, and we are developing an education centre for bats nearby. We are building a website about bats in China, which will include information about echolocation calls and gene sequences.

The Effect of Habitat Fragmentation on Genetic Variation in the Bang's Leaf-nosed Bat, *Hipposideros turpis turpis*

Lázaro M. Echenique-Diaz, Jun Yokoyama, and Masakado Kawata; Division of Ecology and Evolutionary Biology, Tohoku University, Japan

Many studies have shown that habitat fragmentation can have a direct impact on the demographic and genetic properties of species with limited dispersal abilities. However, in volant species such as bats, which are usually regarded as having high dispersal potential, the relationship between habitat fragmentation and genetic variation remains poorly understood. By using six microsatellite loci, Geographic Information System, and Bayesian model selection, we tested the effect of habitat fragmentation on genetic variation in the bat *Hipposideros turpis turpis* in Ishigaki Island, southern Japan. Among the models considered, that including the two connectivity measures used in the analysis (connectivity indexes based on landscape distance and mean suitable-habitat-patch size) showed the highest posterior probability. Spatial simulation of the genotyped, geo-referenced individuals further indicated that panmictic units within Ishigaki Island correspond to current major landscape features. These results suggest that habitat fragmentation can affect genetic variation at spatial scales where dispersal is expected to occur, having significant implications for the conservation of this species.

Bats in a Fragmented Landscape: Impacts of Forest Fragmentation on the Assemblage and Population Genetic Structure of Insectivorous Bats in Malaysia

Matt Struebig[1], Tigga Kingston[2], Zubaid Akbar[3], Adura Mohd Adnan[3], Richard Nichols[1], and Stephen Rossiter[1]; [1]School of Biological and Chemical Sciences, Queen Mary University of London, London E1 4NS, UK; [2]Department of Biological Sciences, Texas Tech University, Lubbock, TX 79409-3131, USA; [3]Faculty of Science and Technology, Universiti Kebangsaan Malaysia, Bangi 43600 UKM, Malaysia

Rainforest fragmentation is of major conservation concern, yet studies of the impacts of this process on Asian biodiversity have been limited. We assess effects of fragmentation on insectivorous bats in Peninsular Malaysia, a vulnerable mammal group in a critical country for bat diversity. We use a combination of diversity analyses, Geographic Information Systems and microsatellite genotyping to investigate differences in assemblages between continuous and fragmented forests; and whether the landscape matrix forms a barrier to dispersal between forest areas. Since 2004, twenty fragments have been surveyed for bats, in addition to seven sites in continuous forest. From current analyses, differences between assemblages in continuous versus fragmented forest are evident, because of variation in bat assemblage composition and structure. Several methods are being used to test for genetic structure across six species with different dispersal capabilities. An individual based analysis reveals substantial genetic differentiation and lack of isolation-by-distance in species with forest specific roosting habits. The opposite trends are apparent for cave roosting species, which are likely to be capable of greater dispersal over fragmented habitat.

Use of a Commercialized Forest by Insectivorous Bats in Victoria, Australia

Patrick Prevett[1] and G. Ambrose[2]; [1]School of Science and Engineering and Centre for Environmental Management, University of Ballarat, Wendouree 3355, Victoria, Australia; [2]University of Ballarat, Mount Helen, Ballarat 3353,Victoria, Australia

The Wombat State Forest straddles the Great Dividing Range 80 km northwest of Melbourne in the Midlands Region of Victoria, Australia. Intensive timber harvesting in the Wombat State Forest in the late nineteenth century has resulted in an uneven-aged tree class distribution. Most areas of the forest are either mature (90–100 years old) or young regrowth arising from the introduction of even-aged harvesting systems in the mid-1970s. The principal eucalypt species are *Eucalyptus obliqua*, *Eucalyptus radiata*, and *Eucalyptus rubida.* Floristically this messmate peppermint gum association is representative of about 25% of the 4 million ha of foothill forest in Victoria and therefore provides a sound benchmark for understanding bat species diversity in the region and the impact of timber harvesting on microbat faunas. I am using Anabat bat call detectors and radio-tracking to assess bat habitat use and the status of populations in response to timber harvesting. Systematic sampling over the last two years has shown that despite the changes in forest structure due to timber harvesting this forest supports substantial populations of at least seven and possibly nine species of microbats. Continuing research is using Anabat survey to identify fine scale habitat preferences of different species at a number of disturbed sites.

Present Status, Threats and Implications for Conservation of Bats in Sri Lanka

Wipula B Yapa[1], P. M. C. Bandara Digana, and W. D. Ratnasooriya; [1]Department of Zoology, Faculty of Science, University of Colombo, Colombo 3, Sri Lanka

Sri Lanka is endowed with a high biological diversity and is claimed to be a biological hotspot in the region. With 30 species, bats represent the largest order of mammals in the country. However, this observation is based on field studies carried out 7–8 decades ago. Since then, the natural forests have been depleted by over 50% and the human population has increased by about five fold, causing drastic impacts on natural ecosystems. Thus, it is imperative to reevaluate the status of the country’s fauna and flora, especially that of bats because of their habitat specificity and low breeding rates. In this paper, we present the current status of Sri Lankan bats with quantitative information for selected sites, based on comprehensive field surveys, and attempt to identify the major threats to bat fauna in the island. Our results are based on field observations between 1995 and 2000 in all six bioclimatic zones of the island and long-term opportunistic observations. Further, periodic observations were made at selected bat roosts to assess the population dynamics. This includes observations at over 400 roosts for which quantitative data were gathered. During our observations a total of 23 species of bats were recorded. It is evident that bats are a highly endangered group. Bats had completely disappeared from eight day roosts that were known to be occupied by six species. We also observed a change in the species composition with decline of population sizes of insectivorous species and increase in fruit bats. The threat to bats is still continuing, probably at a higher magnitude, as evident by the fact that, within the five-year period of the survey, bats have lost 17 stable roosting sites. Loss of foraging habitats and loss or disturbances at day roosts appeared to be the main threats to the bats.

The Role of Karst in the Conservation of Bat Biodiversity
Paul A. Racey; School of Biological Science, University of Aberdeen, Aberdeen AB24 2TZ, UK

There is a good correlation between those areas of the world with high bat biodiversity and karstic areas—those rich in calcium carbonate. Although shortage of calcium is hypothesized as a major constraint on reproduction in bats, there is no clear evidence that bats select karstic areas for access to calcium. Instead, because of the abundance of caves, karst provides them with many roosting opportunities. Roosts are selected according to four main variables: temperature, humidity, airflow, and light intensity. The relative degree of disturbance of the roost may not be a major factor in its selection or continued use. Roosts in temperate latitudes are selected because they are cold and suitable for hibernation and the bats alter their position in the roost with changing winter temperature. Roosts in the tropics are selected because they are warm and suitable for reproduction. This warmth results from convected air from outside the roost or from the body heat of large numbers of bats. Several long-term studies of population ecology of bats have been carried out in karst and have revealed the importance of this habitat for the conservation of bats.

Community Composition of Bat Assemblages in a Vietnamese Karst Protected Area
Neil M. Furey and Paul A. Racey; School of Biological Science, University of Aberdeen, Aberdeen AB24 2TZ, UK

With ca. 100 bat species, a significant proportion of the world’s bat diversity occurs in Vietnam. While knowledge regarding the biogeography of Vietnamese bats remains limited, preliminary data suggest that forested limestone karst areas provide important refuges for bat populations. This paper presents the preliminary results of research at the newly designated nature reserve at Kim Hy, a karst area in north-east Vietnam, which encompasses approximately 150 km^2 and an extensive tract of primary karst forest. Field surveys using harp traps and mist nets have confirmed the occurrence of at least thirty-three bat species at the site to date, including several that are rarely recorded and poorly known. As the site’s location is included in the distribution of many more bat species however, it would seem unlikely that the present inventory is complete. Bat assemblages at the site include four frugivores, while the remaining species are insectivorous and include two that may be opportunistic carnivores and piscivores respectively. We group these species into guilds on the basis of their wing morphology and tentatively identify those that may face a higher conservation risk locally due to their foraging strategies and roost requirements. Bat populations at the site are directly threatened by harvesting for local consumption and loss of foraging habitats due to agricultural encroachment and illegal logging.

Conservation of Bats in Karst Areas of Bohol Island, Philippines

Reizl Pamaong-Jose[1], Sherry P. Ramayla[1], William G. Granert[1], and Apolinario B. Cariño[2]; [1]Soil and Water Conservation Foundation Inc., Central Visayas State College of Agriculture, Forestry and Technology, Main Campus, Bilar, Zamora, Bohol, 6317, Philippines; [2]Bat Count Philippines and FFI-Philippines Biodiversity Conservation Programme Negros Forest Ecological Foundation Inc., Bacolod City, 6100, Philippines

Bohol Island is rich in biodiversity but is one of the least biologically explored islands in the Philippines. The Island is one of the major karst areas in the country and has the highest percentage of karst (> 60%). Karst landscape has a unique type of vegetation that supports a variety of vertebrate fauna. For this reason, an extensive bat survey was conducted for two years (2005–2006) to provide necessary information on the species and their distributions that will serve in formulating priority conservation measures. Trapping effort totaled between 150–175 mist net-nights at each site, with additional effort from harp traps. In total, 27 bat species were recorded, of which ten were endemic species, and five threatened, namely: *Eonycteris robusta, Rhinolophus subrufus, Hipposideros pygmaeus, Acerodon jubatus,* and *Pteropus vampyrus.* This study also included a new record for the Island of Bohol with the sighting of the small island flying fox *P. hypomelanus* in the Municipality of Loboc. Comparing other bat surveys in the Philippines, the current result is exceptionally high in terms of the number of insectivorous bats recorded. This is mainly due to the abundance of caves, which is one of the characteristics in a karst environment. Despite the disturbed nature of the forest surveyed, there were still endemic and threatened species in the area. This implies the urgent need for conservation and protection on Bohol Island.

The Large Bat Caves of Malaysian Borneo

M. T. Abdullah[1], Leslie S. Hall[2], Olswald Braken Tissen[3], Augustine Tuuga[4], and Earl of Cranbrook[5]; [1]Department of Zoology, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak; [2]50 Obi Vale Road, Maleny, 4552, Australia; [3]Sarawak Forestry Corporation, Kuching, Sarawak; [4]Sabah Wildlife Department, Kota Kinabalu, Sabah; [5]Glenham House, Saxmundham, UK

Gomantong Cave in Sabah, Deer Cave at Mulu and Niah Great Cave in Sarawak are well known for their large bat populations. These caves are in National Parks and are popular attractions for local and international tourists who come to watch the evening exodus of bats. It is estimated that around one million wrinkle-lipped bats (*Chaerephon plicata*) exit Gomantong and Deer Caves. The caves also possess a high diversity of bats—Gomantong, 12 species; Deer, 12 species; and Niah, 19 species. These large, bat-occupied, popular tourist caves have a wide range of conflicting management issues. Gomantong and Niah are well known as collection sites of swiftlet nests for the bird's nest soup industry. At Niah, the Naked Bat, (*Cheiromeles torquatus*) has suffered a serious decline in numbers (18,000–20,000 in 1958 to approx 1,000) and the disappearance of a large colony of *Eonycteris spelaea* is of concern. Reasons for the declines are unclear, but pressure from hunting and nearby forest clearing are suspected to be involved. Mining of guano from large areas of the cave floor has caused compaction of the floor and the

loss of associated cave invertebrate fauna at Niah. Fortunately, and probably because of the large size of the caves, the activity of eco-tourists appears to have little impact on the bats. These caves and their bats are highly significant sites and careful management is required to ensure their continued survival.

Ecology, Threats, and Conservation of Kitti's Hog-nosed Bat (*Craseonycteris thonglongyai*) in Thailand

Medhi Yokubol[1], Piyathip Piyapan[1], and Surapon Duangkhae[2]; [1]Department of Biology, Prince of Songkla University, Songkla, Thailand; [2]Wildlife Fund Thailand, Bangkok, Thailand

In the 30 years since discovery, monitored populations of *Craseonycteris thonglongyai* in Thailand have continually decreased. Most populations are found outside protected areas and subject to disturbance from various kinds of human activity. Due to their very small size, *C. thonglongyai* are presumed to have high energetic demands and might need to conserve their energy by lowering activity while roosting in caves. In the present study, preliminary time-activity budget observations indicated low activity of the bats during daytime and there is evidence that colony size in many caves changed negatively with disturbance levels. *C. thonglongyai* have two brief foraging periods and their foraging ranges are confined to within 1 km from the roost cave. Although the bats can forage in many kinds of human altered habitats, they avoid foraging in large open areas of cassava plantations although insects are abundant. Besides roosts and habitats disturbance, unregulated hunting has also posed a serious threat to *C. thonglongyai*. Since most populations are found outside protected areas, conservation strategies typically implemented in protected area may not effectively be applied for this endangered bat. A conservation plan should be set up considering both the ecological and cultural context. The question is how to manage natural resource utilization in a way that sustains both bats and humans. A solution cannot be carried out without appropriate knowledge of roosting and foraging ecology of *C. thonglongyai*.

Bat Fauna of Cambodia

Vitaliy Matveev[1] and Gábor Csorba[2]; [1]Okada's Laboratory Graduate School of Bioscience and Biotechnology Department of Biological Sciences Tokyo Institute of Technology, Midori-ku Yokohama 226-8501, Japan; [2]Hungarian Natural History Museum, Budapest, H-1083, Hungary

Forty-nine bat species have been registered in the course of the six expeditions to Cambodia from July 1998 through March 2007, expanding the country's list of bat species to 59 (57 confirmed and 2 provisional). Sixteen of them, namely *Macroglossus sobrinus*, *Taphozous theobaldi*, *Hipposideros cineraceus*, *H. galeritus*, *Rhinolophus pusillus*, *Rh.* cf. *sinicus*, *Glischropus* sp., *Myotis horsfieldii*, *Murina peninsularis*, *M. cyclotis*, *M. tubinaris*, *Kerivoula* sp., *K. kachinensis*, *Miniopterus schreibersii*, *M*. sp. and *Harpiocephalus harpia*, as well as two species provided by J. L. Walston—*Saccolaimus saccolaimus* and *Myotis ater*—are reported from Cambodia for the first time or were recently reported by ourselves elsewhere. Occurrence of *Rousettus leschenaultii* and *Pteropus hypomelanus* has been confirmed. Specific distinctiveness of *Murina peninsularis* has been proved, while that of *Harpiocephalus mordax* has been rejected, based on the combined morphological and molecular genetic datasets. The latter taxon should be regarded as a junior synonym of *H. harpia*. Two species, namely *Glischropus* sp. and *Miniopterus* sp., most likely represent species new to science: it is a subject

of ongoing research. In general, Cambodian bat fauna could be characterized as typical Indomalayan, with 71% of its registered species not occurring outside the region. It is lacking species common in the neighboring zoogeographic regions, with only *Miniopterus schreibersii* found throughout the Old World, Australia and Oceania.

Distribution Trends of Bat Fauna in the Northern Western Ghats Region of India

Vishakha Korad; Department of Zoology, Fergusson College, Pune- 411004, India

The study on bat species diversity was carried out in northern Western Ghats of India between 17^{0}.54' to 19^{0}.24' North and 73^{0}.19' to 75^{0}.10' East, covering an area of about 15,642 square km. Hills in this region are 500–1000 m and more in altitude, low extensions of hills on flat land or spurs are 250–500 m in height, and plains extending eastward are dry and hot. The hilly region is rich in caves in basalt and laterite rocks, and experiences monsoon of about five months and average rainfall is 4,750 mm. The forests appear in the form of scattered, inaccessible evergreen and semi evergreen forests. Dryness increases gradually towards the spurs and plains. The spurs are characterized by scattered cover of deciduous forest and the presence of small and narrow caves. This area is also rich in perennial water sources. The plains are relatively hot, dry and irrigated by water canals. Of the 30 bat species recorded from the study area, 37% of species are reported from all of the three topographically and climatically distinct zones. About 53% of species prefer to live in hills, while only 10% prefer the dry and hot plains. Nine bat species (30%) reported from the study area are exclusively evergreen forest species and are never reported from the spurs or plains. Three bat species of the plains—*Megaderma lyra, Tadarida plicata,* and *Scotophilus heathii*—seem to be adapted to dry and hot weather and are attracted by the abundance of food. Spurs should also be given priority for conservation, as approximately 37% of the species prefer this area rather than hills or plains and reported mostly around urban or rural areas.

Ecological Distribution of Bats at Lore Lindu National Park Central Sulawesi

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The long-term study of bats was carried out from March 2000 to July 2001 in Lore Lindu National Park, Central Sulawesi, Indonesia. Bat diversity of 17 habitat types, derived from the combination of 11 major vegetation types distributed from 350 m to 2100 m above sea level, was sampled. To standardize mist net effort, each survey site was sampled for four days with five mist nets per night to give a total of 20 mist-net nights per location. A total of 31,233.6 m^2 of mist-net night area was set during this survey. A total of 16 species of Megachiroptera (fruit bats) have been identified in the Park. Using Euclidian distance dissimilarity index (EDD), the 16 species were clustered into four groups at EDD=1.9. The long rostra and elongated tongues of three genera, *Macroglossus, Eonycteris,* and, to a lesser extent, *Rousettus,* suggest an important role in pollination. The pollinators seem to be divided into three groups: *R. bidens* has a role at higher elevations, *Rousettus linduensis* and *Macroglossus minimus* at middle elevations, and *Rousettus amplexicaudatus* and *Eonycteris spelaea* at lower elevations. The results of clustering analysis are almost supported by Principle Component Analysis where PC1, PC2, and PC3 accounted for 71.94%, 27.39%, and only 0.34% of the total variance, respectively. We suggest that PC2 primarily implies altitudinal gradient and that PC1 is associated with some factor that differs substantially between the higher mountain areas and lowland areas, and is likely related to a humidity gradient.

Bat Surveys of the Ira Lalaro–Paitchau Range Tropical Forest, Timor-Leste
Kyle N. Armstrong[1], Colin R. Trainor[2], Damian J. Milne[3], and Chris R. Pavey[4]; [1]Molhar Pty. Ltd., Western Australian State Agricultural Biotechnology Centre, Murdoch University, Perth, Western Australia; [2]School of Science and Primary Industry, Charles Darwin University, Darwin, Northern Territory, Australia; [3]Department of Natural Resources, Environment and the Arts, Palmerston 0831, Northern Territory, Australia; [4]Department of Natural Resources, Environment and the Arts, Alice Springs 0871, Northern Territory, Australia

The bat assemblage of pristine and secondary forests of the Ira Lalaro–Paitchau Range in Timor-Leste has received little scientific attention for many years. This area contains the last remaining tropical evergreen and tropical dry forests in the country, and much of it is represented in the new Conis Santana National Park. A recent hydropower development proposal provided the opportunity for baseline surveys to be undertaken as part of standard environmental impact assessments. Surveys were conducted in March 2004 and October 2006, which included harp trapping, mist netting, cave searches and acoustic detection (ZCA and time expansion systems) of bat echolocation calls. At least 20 species of bats were recorded from the project area and the surrounding region. Following a literature review, a list of at least 31 bats currently recognized as occurring on the island of Timor was compiled. Thus, the bat assemblage in the eastern tropical forests is relatively diverse, and local diversity might be shown to be higher with further effort. Several taxa new to the island were recorded, including two *Murina* (aff. *cyclotis* and aff. *florium*) and a *Kerivoula* (aff. *hardwickii*). Genetic analysis of these is being undertaken as a first step to resolve their identity. Only one endemic species was captured, *Rhinolophus montanus*, which has not yet been ascribed conservation status following its split from *R. philippinensis*. It was also recorded at low altitude in disturbed riparian vegetation east of Manatuto, and two phonic types were present. Several other taxa are represented by endemic subspecies on the island of Timor—*Rhinolophus canuti timoriensis, R. celebensis parvus, Hipposideros bicolor hilli, H. sumbae* aff. *rotiensis*)—which will likely benefit from the preservation of habitat in the Conis Santana National Park.

Temporal Variation of Insectivorous Bat Assemblages at Krau, Malaysia
Rakhmad Sujarno Kudus[1], Tigga Kingston[2], and Zubaid Akbar[1]; [1]Faculty of Science and Technology, Universiti Kebangsaan Malaysia, Bangi 43600 UKM, Malaysia; [2]Department of Biological Sciences, Texas Tech University, Lubbock, TX 79409-3131, USA

We investigated the temporal variability of bat assemblages in undisturbed rainforest at local and landscape levels in the Krau Wildlife Reserve in Peninsular Malaysia. Three sampling replicates were undertaken between 2002 and 2005 at five selected study sites within the reserve. Harp traps yielded 15,976 individual captures belonging to 38 bat species from 6 families. The number of captures decreased by 44% in the second year, but was relatively stable in the third year except at one site. Similarly, the number of individuals decreased by 40% in the second year, was relatively stable in the third year. Three species dominated assemblages, comprising 52% of the total individuals captured. Species diversity in all sites was stable over the three years and recapture rates of all species declined. Turnover rates were generally low, whereas species composition was similar over the three years in each of the study grids. Trapping completeness was predicted to be more than 80% based on five species richness estimators. The factors thought to influence temporal variability of insectivorous bat assemblages at the local and landscape levels in an undisturbed habitat are discussed and will assist the relevant authorities when formulating management and conservation strategies.

Use of DNA Barcodes to Understand Southeast Asian Bat Diversity

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We sequenced DNA barcodes (655 base-pair segments of the cytochrome *c* oxidase subunit I gene) from 1200 specimens of approximately 165 species of bats from Southeast Asia and southern China to determine their utility for discriminating and identifying species. In all but three cases, specimens identified as morphologically or acoustically distinct could be discriminated using DNA barcodes, based on K2P-corrected sequence divergence. This indicates that DNA barcodes are generally an effective tool for identifying known species, and in particular for matching up identifications of specimens collected and stored in different locations. In addition, in many cases (particularly within genera *Kerivoula*, *Murina*, *Rhinolophus*, *Hipposideros*, and *Myotis*), DNA barcodes revealed multiple lineages with deep (over 3% sequence divergence) divides within putative morphological species; in some cases specimens supposedly of the same species were not each other's nearest neighbors. This suggests that species diversity within the region may be substantially underestimated. However, most species with samples from widely disparate geographic areas (e.g., Borneo and Peninsular Malaysia, or Peninsular Malaysia and mainland Southeast Asia) showed a geographically structured pattern of genetic distances, though usually less than differences between recognized species in the same genus. This emphasizes the fact that genetic differentiation alone does not necessarily indicate speciation. Further analysis using morphological and acoustic data as well as genes with a different inheritance mechanism and rates of mutation will be necessary to determine which cases represent previously unrecognized species or subspecies. DNA barcodes appear to be an efficient tool for identifying areas in need of focused taxonomic research to clarify species boundaries.

Endemics as Conservation Priorities: Large Flying Foxes as an Example of the Challenge Conservation Managers Face

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It is now the norm that Philippine wildlife species are living in lower quality habitat among fragmented landscapes due to large-scale land-use change, and it is important that we track the effect of those changes on species of concern. Because not all species respond to anthropogenic disturbance in the same way, ecological communities are not simply reduced monotonically by the reduction of habitat, but rather also suffer a skewing of their numbers and interactions. Philippine endemics are especially at risk, both because of their limited distributions, but also because many Philippine endemics are native habitat specialists and may be particularly sensitive to disturbance. Using Philippine large flying foxes as an example, we compare the current conservation status of the endemic, *Acerodon jubatus*, to its non-endemic roost-mate, *Pteropus vampyrus*, and discuss conservation implications. The endemic species is found in fewer roost sites (< 1:3) than the non-endemic, and in these roosts the population sizes of the endemic are much smaller (< 5% total colony) than the non-endemic populations. The species' sympatry, similar appearance, and endangered listing status, pose a challenge to conservation managers. We recommend Philippine biologists and managers focus efforts on developing much-needed baseline information for endemic species.

Hunting, International Movement, and the Need for Regional Conservation of Flying Foxes (*Pteropus* spp.)

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Old World fruit bats are ecologically vital seed-dispersers and pollinators. They are threatened globally from hunting and habitat loss, and despite reported population declines, information on baseline population, migratory movement, and the impact of hunting is lacking. In Peninsular Malaysia, year-round hunting of flying foxes (*Pteropus* spp.) is pervasive. In order to characterize the threat of hunting to populations of *Pteropus* species in western Malaysia, we performed repeated roost-site counts at several locations across the country, and fitted satellite transmitters on seven *P. vampyrus* from 2003–2006 to track their local and long-range movements. We also quantified the minimum impact of hunting using license data from the national wildlife department. The largest colony size for *P. vampyrus* was estimated to be between 6,000–8,000 individuals, and approximately 4,500 for P. *hypomelanus*. The maximum legal bat harvest for the period 2002–2005 was 87,800, based on licenses issued, but this underestimates the number of bats actually killed due to underreporting by hunters and unlicensed hunting activity. Hunting licenses were issued between 2002 and 2004 at more than twice the rate they were between 1990 and 1996 and theoretical models suggest that current hunting rates are unsustainable. Satellite tracking shows that *P. vampyrus* is highly mobile, foraging up to 59 km per night and traveling hundreds of kilometers between roosting sites. Bats collared in Malaysia were seen to roost and feed in Malaysia, Indonesia (Sumatra), Singapore, and Thailand. Flying foxes depend on habitat that transcends national boundaries, and while their protection status varies among Southeast Asian countries, current hunting practices within Malaysia may not be sustainable. This emphasizes the need for protection of these ecologically important species under a regional cooperative management plan among Southeast Asian countries.

Hunting and Trading of Large Flying Foxes in and around Palangka Raya, Central Kalimantan, Indonesian Borneo

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We documented hunting of *Pteropus vampyrus natunae*, the Bornean subspecies of the large flying fox, in and around Palangka Raya, Indonesian Borneo, between 2003–2007. We interviewed hunters and market vendors, and surveyed hunting rates and areas in the favorite hunting site. Areas of forest averaging 355 m^2 are cleared and canopy-level nets erected to trap bats flying to feeding trees. In 2003, we observed the removal of 4,500 animals in a single 30-day period during the peak-hunting season, and interviews with hunters indicate that even greater numbers of bats were hunted in the early 1990s. Consumption of bat meat is believed to help alleviate respiratory ailments and demand in Palangka Raya is high. Despite this continuing demand, the number of bats for sale and number of hunters/hunting areas being used has declined in recent years, indicating that over-intensive past hunting has led to severe population declines. This suspicion is supported by data on flying-fox reproductive rates, which indicate that an imposed mortality of only 10% can cause population size to halve in just six years. It remains to be seen whether populations will recover following recent declines in hunting intensity.

Status of the Formosan Flying Fox on the Green Island, Taiwan

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Green Island is located in the east southern margin of Taiwan. In the past decade, rapidly developed tourism has been dramatically changing its ecological environment. The Formosan Flying Fox, *Pteropus dasymallus formosus*, found in the wild on mainly the Green Island, was previously thought likely extinct. Intensive survey over the island was carried out since August 2005 to examine the status of this species on the Green Island. Three individuals were rediscovered, which was the only known colony surviving. Questionnaires for the elder residents were undertaken to document the local natural history. Partnerships with schools, government departments, conservation organizations, and local community were progressively built. The activity pattern of the Formosan Flying Fox was recorded and the major activity area was identified. These survey results can be used to identify ecologically important habitat for conservation management.

Are Fruit Bats of India Really Vermin?

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Among the 13 species of fruit bats in India, *Pteropus giganteus, Rousettus leschenaulti*, and *Cynopterus sphinx* are very common. They usually live at the surface level occupying trees, ruined buildings, and foliage. The remaining 10 species live at higher altitudes of 500 to > 2000 m. Their distribution and foraging activities are unknown. Among them, *Pteropus faunulus* and *Latidens salimalii* are endemic species. Although *P. giganteus, R. leschenaulti*, and *C. sphinx* feed upon commercial fruits, their role in pollination and seed dispersal of economically important plants (e.g., *Ceiba pentandra*, *Bassia latifolia,* and *Parkia* spp.) cannot be ignored. There is no report on visits of the other species to commercial orchards. Our study suggests that *Muntingia calabura* may be used as inter crop at orchards to reduce damages by *C. sphinx*. Because public and conservation planners are still unaware of their beneficial role, fruit bats are categorized as ‘vermin’ (except *L. salimalii*), and placed in Schedule V of the Indian Wildlife (Protection) Act, 1972 and amended Acts. Now it is *high* time for the Government of India to reopen the issue and to consider removing these eco-friendly flying mammals from the list of vermin in the Wildlife (Protection) Act.

Biodiversity, Bats and Buddhism: Protecting *Pteropus* in Thailand

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Basic conservation status data for *Pteropus* fruit bats in Thailand are limited, though preliminary research and informed anecdotal evidence indicate progressive population decline due to habitat loss, decimation due to perceived threats of retroviral disease transmission to humans, and persecution due to superstition. *Pteropus* population trends have not been systematically monitored over time in Thailand, nor have habitat size and integrity. The role of anthropogenic structures and sanctuaries (notably Buddhist *wats*, or temples) in conservation has not been systematically explored, though it is evident that the protection afforded by *wats* may play a major role in protecting *Pteropus* populations: 13 of 16 known bat camps in the Central Plains occur within the grounds of temples. Benchmarking of population and habitat attributes is critical, and engagement with local religious leaders and landowners is potentially an extremely powerful tool for conservation. Two priorities emerge: 1) Baseline research on distribution and abundance of *Pteropus* in Thailand, and 2) basic conservation outreach to communities harboring fruit bat populations, to protect remaining populations and ensure their survival throughout the country. This paper proposes a study that will: a) provide missing baseline distribution and abundance data, b) identify vulnerable *Pteropus* populations nationwide, c) raise awareness of local communities about bat conservation, d) accurately delineate *Pteropus* habitat boundaries using GPS technology, and e) encourage the involvement of local land managers in bat and habitat protection.

Bats and People—'Making Connections'
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Kadoorie Farm and Botanic Garden (KFBG) comprises 148 hectares of native secondary forest, botanic garden, and organic agricultural terraces. The centre includes a wild animal rescue program and live native animal exhibits. KFBG frequently faces many of the issues and conflicts encountered by nature reserves and human settlements in the region. The unique setting and diverse activities provide an opportunity to engage visitors in a way that should help them make wider connections with environmental issues, and link these with their own lives. KFBG maintains colonies of two bat species (*Cynopterus sphinx* and *Rousettus leschenaulti*) that consist of orphaned or rescued individuals. This paper suggests an education model that will help connect the KFBG native bat displays with cultural heritage, conflict resolution and the health of our regenerating forests. The strategy aims to make 'connections' through signage and activities that will raise public awareness not only with respect to the life of the bat, but also to their own lives. Stories promote understanding of the important role of bats in the environment, and the unexpected consequences of breaking ecological links. This knowledge is essential in helping society understand how our lives remain connected to the natural world—a world viewed increasingly from a distance.

Going Batty among Blocks—Bat Outreach in an Urban Jungle
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In highly urbanized cities such as Singapore, citizens tend to become alienated from nature due to greater distancing from direct interaction with wildlife. Public outreach to create awareness about nature is thus crucial to generate interest about wildlife, dispel myths and hopefully promote conservation of natural habitats. Children hold the key to the success of conservation in the future. Hence the development of an outdoor kids' program called "Fun with Nature" initiated by the Nature Society (Singapore) for kids 5 to 9 years old. Pooling resources with the National Institute of Education and the National Parks Board, the Nature Society has conducted four "Fun with Bats" sessions, which have reached out to over 200 primary school kids and their families. This session will elaborate on the structure and content of the "Fun with Bats" program. Benefits and challenges faced in running such a program will be discussed. Other efforts at bat education such as growing "bat gardens" and creating bat sanctuaries in schools will also be shared.

Cultural Festivals: Implications for Bat Conservation on Negros Island, Philippines
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Annual cultural festivals have been a tradition in many cities and provinces of the different regions of the Philippines. These festivals attract tourists both nationally and internationally.

Aside from sharing the traditional culture, history, and myths of each city or island where the festival is held, wildlife themes are now incorporated to showcase the diversity of flora and fauna in each area. A lot of celebrations from different Provinces in the Philippines have adopted this concept. Among these wildlife-themed festivals are the “Langub” or Cave Festival of Mabinay and the “KaSuLAD” Festival of Pamplona, municipalities of the Province of Oriental Negros, and the Mud Pack Festival of Mambukal, Murcia, Negros Occidental. These festivals depict the life and ecology of bats and swifts living in caves and on trees and how they forage in the night and eventually adopted and survived feeding in agricultural areas of the Island. This paper further discusses the impact of these presentations on the status and conservation of bats on the Island. Sustainability of this event is also documented among the participating local government units along with the interpretation by choreographers and artists of the ecology of bats in their presentation concepts. It is hoped that this cultural appreciation will help sustain the conservation and awareness of bats throughout the Island of Negros and the country as a whole.

Development as a Threat to Biodiversity: What Role Do Conservation Organizations Play? (The Boracay Island Experience)

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Boracay Island, off the coast of Kalibo, Aklan, Panay Island is a prime international tourist destination in the Philippines. It has been subjected to unregulated development for the last few years, resulting in a depletion of water sources and diminished water quality as well as waste management problems. These developments were also detrimental to the existence of the flying foxes roosting in the area. The construction of road systems along their roost areas is likely to eventually extirpate the bats in their natural habitat. Thus, concerned individuals, conservation organizations and groups initiated a campaign centered on the conservation of the bats’ roosting sites and their habitat on the Island. This paper discusses the processes by which the initiatives were implemented to counter the ongoing development in the area. Apart from the proposed management plan formulated by the group, a bat learning center will be established to provide awareness on the importance of bats both for the local and international audience.

Bats and SARS: Environmental, Cultural and Economic Drivers for Disease Emergence

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The emergence of SARS and its subsequent rapid global spread caused alarm in public health circles worldwide, in large part because of the unknown etiology and origin of the outbreak. When a previously undescribed novel coronavirus (Coronaviridae) was shown to be responsible, the origin of the outbreak and the source of the infection became a major focus of attention. Investigation of the features of the earliest human cases suggested an association with wildlife and ‘wet’ market in the Pearl River delta area in southern China. Concurrent evidence of

infection in civets and other species in wet markets supported this. However, we were unconvinced that these species were the true reservoir in nature, and hypothesized that infection spilled from a less frequently traded natural reservoir species to civets and other immunologically naïve species in the markets or somewhere along the wildlife supply chain. We targeted bats in southern China for surveillance and found serologic and molecular evidence of a group of viruses very closely related to SARS-CoV in several species of horseshoe bats (genus *Rhinolophus*, family Rhinolophidae). The SARS-CoV isolates from both humans and civets sit phylogenetically within the group of bat viruses, strongly indicating that the virus responsible for the SARS outbreak originated from this group of viruses. We contend that increased trade and trafficking of wildlife has facilitated the emergence of SARS. A rich cultural heritage underlies wildlife consumption in China, and different species and dishes are favored for a range of social, business, and health reasons. But the demand for, and consumption of, wildlife in southern China has increased in recent years, purportedly associated with improved economic conditions. An increase in legal and illegal wildlife trade has paralleled this demand, with animals reportedly channeled from many and various locations in Southeast Asia. The significance of cultural and economic drivers on disease emergence is increasingly being recognized. Parallels between the wet markets and SARS in China, and the bush-meat trade and HIV-like viruses in Africa are evident. The need for a combination of 'hard' and 'soft' sciences in investigating disease emergence, and a 'big-picture' view in identifying drivers for emergence is increasingly evident.

The Temporal Dynamics of Nipah Virus Infection in *Pteropus hypomelanus* (*P. hypomelanus*) in Peninsular Malaysia

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Bats of the genus *Pteropus* were identified as a reservoir for Henipaviruses (Family Paramyxoviridae) after the emergence of Hendra virus in Australia in 1994 and Nipah virus (NiV) in Malaysia in 1999. In 2000, evidence of Nipah virus infection was found in *Pteropus hypomelanus* and *P. vampyrus* in Malaysia and *P. lylei* in Cambodia and Thailand. These findings suggest that Nipah virus is endemic to Southeast Asia and circulates in pteropodid bats. However, the factors that determined the viral prevalence within *Pteropus* species are unknown. Therefore, we conducted a longitudinal study on a resident colony of *P. hypomelanus* in Tioman Island to determine risk factor(s) that could play important role(s) in the infection. Bats were non-randomly and purposively sampled every four to six weeks from January 2004 to June 2005 at their roosting site using mist nets. A total of seven samplings were completed. Samples of urine, saliva, and serum from 690 bats were collected. All serum samples were tested for NiV-neutralizing antibodies. The risk factors that were examined were age (juvenile, age from 3 months to 2 years and adult, age more than 2 years), sex (males and females), reproductive status; lactating status (lactating females vs. non-lactating females), carrying a pup (carrying a pup vs. non-carrying a pup females) and pregnant (pregnant vs. non-pregnant females). The pups (less than 3 months old) were excluded from the analysis due to the assumption of passive immunity conferred by seropositive dams. The seroprevalence of sampling times ranged from 2–15% and the antibodies titers ranged between 1:10 and 1:320. Neutralizing antibodies were detected in all age groups, sex, and reproductive status. Based on statistical analysis, factors such as lactating females (p = 0.011, OR = 6, 95% CI: 1.12, 32.25) and carrying a pup females (p = 0.008, OR = 30, 95% CI: 1.61, 500.00) had higher odds of being seropositive. They may therefore play important roles in the seroprevalence to Nipah virus in this species. The findings in juvenile animals (> 2 years old) suggested that the bats in the colony might have maintained the infection for at least 2 years prior to the time when the samples were collected. However, no virus was isolated from any of the samples collected at any point during the period of study. This may indicate a low viral transmission between the animals in this colony.

Population Genetic Structure in the Black Flying Fox (*Pteropus alecto*)
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Pteropid bats appear to be a natural host for the recently emerged fatal zoonoses Nipah virus, Hendra virus, and Australian bat lyssavirus. The Black Flying Fox (*Pteropus alecto*) has a range exceeding 1.6 million km^2 and is found between latitudes of 1° north and 34º south. Elucidating the population structure of the black flying fox will contribute to understanding the viral ecology of these zoonoses and has implications for disease risk management in the region. Four subspecies are currently recognized: *P. a. alecto* from Sulawesi, Salayer, and Lombok; *P. a. aterrimus* from Bawean and Kangean Islands; *P. a. morio* from Sumba and Savu; *P. a. gouldi* from eastern and northern Australia and southern New Guinea. To examine population structure in *P. alecto*, we nucleotide-sequenced a 425 base pair fragment from the mitochondrial control region from individuals from Sulawesi, Sumba, Savu, and across the species range in Australia. Phylogenetic analysis revealed clear structuring within the species with individuals from Sulawesi (*P. a. alecto*) forming a strongly supported clade, which is the sister to a second clade found in Sumba, Savu, and Australia (*P. a. morio* and *P. a. gouldi*). This second clade is further divided into a clade containing individuals from only eastern Australia and a clade containing individuals from Sumba, Savu, and eastern and northern Australia with haplotype lineages shared between Australia and Indonesia (Sumba and Savu). Detailed assessment of the degree of gene flow between regions will assist in assessing the risk of disease transfer between geographic regions.

Population Genetics and Phylogeography of Flying Foxes in Southeast Asia
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Little is known about the long-distance movement or population structure of flying foxes (Genus: *Pteropus*) despite their importance as pollinators, seed dispersers and as natural reservoir hosts of emerging, zoonotic Henipaviruses. I examined the genetic structure of large flying foxes in Southeast Asia to better understand the ecology and dispersal of four species: *P. vampyrus*, *P. hypomelanus*, *P. lylei*, and *P. giganteus*. Over 300 individuals of the four species (with most extensive sampling for *P. vampyrus* and *P. hypomelanus*) from across Southeast Asia have been sequenced for ~800 bp of the mtDNA control region. Investigations are underway using other mtDNA markers, including cytochrome *b* and ND5, and ~10 nDNA microsatellites markers. Preliminary data show a lack of population structure for *P. vampyrus* across a wide geographic range of 1000s of kilometers, but strong population structure for a co-distributed species, *P. hypomelanus*. Genetic estimates of dispersal and gene flow for *P. vampyrus* are corroborated by satellite telemetry studies from Peninsular Malaysia that have recorded extensive inter-population movement. Results suggest that species-specific management strategies are necessary to effectively conserve *Pteropus* spp. in Southeast Asia. For *P. hypomelanus,* site-specific protection is needed to preserve genetically-distinct island populations; and for *P. vampyrus,* international cooperation is required to effectively manage populations for the purposes of conservation and public health.

Roosting Ecology of Daubenton's Bat in Relation to the Epidemiology of European Bat Lyssavirus 2

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Because it hunts almost exclusively over water, there have been many studies of the foraging behavior of Daubenton's Bat *Myotis daubentonii*, but few on its roosting ecology. Following the death of a Scottish bat worker in 2002 from European bat lyssavirus 2 (EBLV-2), for which Daubenton's Bat is the principal vector, a study was established to investigate the roosting ecology of this bat, especially the extent to which it roosts in proximity to man and other bat species. Forty-six individuals from five colonies were radio-tracked during summers 2004–2006. The duration of roost occupancy and the frequency of switching between roosts varied according to whether the bats roosted in trees (n = 56) or buildings (n = 12). During the study period, maternity roosts were identified in two occupied buildings and seven trees. All roosts were usually located less than 500 m from rivers or lochs. All roosts used by females from the same colony were usually within 1 km radius. Females that formed maternity colonies in buildings were more faithful to them than those that formed such colonies in trees. All bats usually had one major foraging site close to their roosts, but lactating females had an additional site further away. The Soprano Pipistrelle *Pipistrellus pygmaeus* and the Brown Long-eared Bat *Plecotus auritus* formed maternity colonies in the same building as Daubenton's Bat. During lactation, soprano pipistrelles including juveniles emerged from many tree holes used by Daubenton's Bat suggesting that they may form maternity colonies in the same roosts.

Bat Flies: Obligate Ectoparasites of Bats (Mammalia: Chiroptera)

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Bat flies (Diptera: Nycteribiidae and Streblidae) are conspicuous blood-feeding ectoparasites of bats worldwide. Their intimate relationships with bats produce myriad emergent properties for the study system, making it ideal for studying ecology and evolution. For the phylogeneticist, bat flies constitute a manageably sized group with fantastically divergent morphologies, whose evolution can be understood with a completed phylogeny. Opportunities for study of cospeciation and coevolution with bats are rife. For the biogeographer, bat flies exhibit the ultimate "checkerboard" distribution, with most fly species restricted to individual host species.

On the other hand, individual bats sometimes harbor two to four coexisting species of bat flies. When they do, the species often co-occur more frequently than expected at random. For the ecologist, co-occurring species of bat flies are hyper-dispersed in morphological space, indicating intense competition for distinctive microhabitats on the host. Phylogenetic studies show instances of convergent evolution, involving clades that adopt a common strategy for exploiting the fur and skin substrates of their hosts. Their K-selected reproductive strategies have many life-history consequences (densities, reproductive rates), and may ultimately contribute to male-biased sex ratios, which are otherwise uncommon in blood-feeding ectoparasitic insects. We have also found that properties of bat roosts (e.g., durability and protection) significantly affect the quality and quantity of parasitization by flies. The roosting diversity of bats (as well as their roost-switching behaviors) may be responses to reduce parasitism. The inclusion of ectoparasite studies significantly enhances the scope and power of research programs with bats. The ease with which bat flies can be collected, identified, and studied, coupled with the tremendous accompanying increase in research opportunities, should motivate bat researchers to consider the addition of ectoparasites to their field and research programs.

No Island Is an Island: A Test of Pollination by Bats and Birds on Guam
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Both megachiropteran bats and birds are regarded as key to the survival of native forests, and on Pacific islands, flying foxes have been considered keystone to native ecosystems. I tested this theory on the Pacific Island of Guam where the introduction of a predator, the brown tree snake, has effectively eliminated all frugivorous and nectivorous birds. There are fewer than 100 Marianas flying foxes remaining and they are concentrated in one area. Because snakes are a relatively recent introduction, native forest plants still persist. To examine the role of animal pollination, I followed the flowering and fruiting of all native plant species known to be pollinated by bats and birds in addition to the most abundant native forest trees. All of the 35 plant species set fruit. I divided the plants into three groups based on floral morphology: 1) extremely small flowers, 1–2 mm, that are unlikely to be pollinated by birds or bats; 2) nocturnally blooming, sweet smelling flowers with extremely thin corolla tubes that are pollinated by nocturnal moths; and 3) species with larger flowers that are pollinated by bats and birds. I then tested the amount of outcrossing and self-compatibility in the bird and bat pollinated flowers. Of the 11 species visited by birds and bats, two were 100% self-compatible. The remainder were pollinated by recently introduced insects that have effectively replaced the native vertebrate pollinators.

Does Pollination Success of *Oroxylum indicum* Vent. (Bignoniaceae) Depend Solely on the Nectarivorous Bat, *Eonycteris spelaea* Dobson (Chiroptera: Pteropodidae)?
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Although pollination generalists dominate tropical plant communities, pollination specialists appear to be at a greater advantage in tropical ecosystems in which pollinators are numerous and many plants flower synchronously. The present study determined the breeding system and legitimate pollinators of *Oroxylum indicum* Vent., which was previously indicated to be pollinated solely by the nectarivorous bat, *Eonycteris spelaea* Dobson. *Oroxylum indicum* exhibits steady state flowering, with one or two flowers per inflorescence opening each night.

Flowers open in the evening and drop off shortly after midnight, while its bilabiate stigma is highly sensitive and quickly closes upon being touched. *Oroxylum indicum* is self-incompatible, which is predominantly found in the Bignoniaceae. Cross pollination yielded the highest pollination success (44%) followed by open pollination (30%), with no fruit set found from insect pollination. It is confirmed that a fruit bat, which was consistently identified from photographs as *Eonycteris spelaea*, is the legitimate pollinator. In each night, bats visited flowers 65 ± 3.5 times, although the first visit after the flower opening appears to be the most important for female reproductive success. Very low fruit set in *Oroxylum indicum* suggests that natural pollination failure regularly occurs, partly as a result of limited pollen received from its stigma sensitiveness. Compared to pollination generalists, the likelihood of pollination failure resulting from population declines of *Eonycteris spelaea*, which is currently occurring in some areas, will be much more intense in *Oroxylum indicum*. Thus, protecting bats and their cave roosts is necessary for maintaining natural crop yields of this plant.

The Cave Nectar Bat (*Eonycteris spelaea*) Is the Major Pollinator of Petai (*Parkia speciosa* Hassk. and *P. timoriana* Merr.) in Southern Thailand

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Although fruit bats are regarded as the principal pollinators of most *Parkia* species in both the Neotropics and Palaeotropics, verification from pollination experiments has been rarely undertaken. The present study aimed to determine the breeding system of the economically important canopy trees, *Parkia speciosa* and *P. timoriana*, and to identify their pollinators. Inflorescences of both species comprise specialized flowers closely packed in a biglobose head, with an average of 2,422–3,860 flowers per capitulum respectively, 70–75% of which are fertile. Although structurally hermaphrodite, some fertile flowers are functional staminate, resulting in a polyad:ovary ratio of 4,700:1. The stigma is receptive shortly after anthesis, which occurs in early evening. Each capitulum flowers for one night. Fruit bats, mainly *Eonycteris spelaea*, continuously visit flowering plants from dusk until after midnight. Nocturnal and diurnal insects (moths and stingless bees respectively) visit capitula, mostly at the nectar zone. Pollination experiments carried out in 28 *P. speciosa* and 4 *P. timoriana* indicated that they are essentially self-incompatible. Open pollination resulted in the highest fruit set (58–62%) although this was not significantly different from hand cross pollination (43–45%). Insect pollination resulted in fruit set of 13% in *P. speciosa*. Nectarivorous bats are thus the most effective pollinators for these chiropterophilous plants.

Foraging Behavior of Pteropodid Bats in the "Big-bang" Flowering Tree *Bassia latifolia*

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Mahua tree (*Bassia latifolia*) is a seasonal flowering tree with nocturnal anthesis. The Indian Short-nosed Fruit Bat (*Cynopterus sphinx*) and Indian Flying Fox (*Pteropus giganteus*) are the main visitors of the tree during flowering period. Spatial and temporal variation in foraging is found between these bats. *P. giganteus* lands on the canopy and consumes fleshy petals and moves downward whereas *C. sphinx* feeds on under storey petals and move upwards. *In situ* consumption is observed in *P. giganteus* and *ex situ* consumption is observed in *C. sphinx P. giganteus* consumes three to eight petals at a time, sucks the juice, and spits out the fibrous remains. Other than foraging, fights such as chasing, biting and emitting agonistic calls were also observed. The larger bat *P. giganteus* spent more time in the tree than *C. sphinx*. The fleshy corolla of the flower is removed by *C. sphinx* and taken to nearby feeding roosts for consumption. The foraging activity of *C. sphinx* involves short hovering flight followed by landing and removal of corolla by mouth. The muzzle of the bat is covered with pollen grains in this process aiding cross pollination. Bat pollinated inflorescences give more fruit set than the bagged ones and reveal that the corolla reward to the pollinators is an evolutionary adaptation.

Foraging Behavior of the Short-nosed Fruit Bat *Cynopterus sphinx*

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The foraging behavior of frugivorous bats, such as utilization of resource patches, changes in the feeding location and dietary differences between males and females are documented in this study. The radiotelemetry studies were carried out using five males and five females for a total of 81 nights. Throughout the study only one male (M4) was found to exhibit night roost fidelity, using the tree *Guetterda speciosa* as a night roost constantly. But other tagged bats of both sexes used more than one night roost. Four of the five males used a single foraging area. The mean commuting distance for males was 0.22 ± 0.19 km and the mean size of the foraging area was 0.75 ± 0.27 km^2. All the females were found to be utilizing more than one foraging area. The mean commuting distance for females was 2.1 ± 1.0 km and the mean size of the foraging area was 0.83 ± 0.12 km^2. The males and females exhibit a high level of activity during the early hours of night soon after emergence and another activity peak during pre-dawn hours. These differences in the behavioral repertories of subadult males and females appeared to reflect the behavior of adults.

Role of *Pteropus giganteus* (Indian Flying Fox) as an Agent of Regeneration of Wild *Ficus* spp. around Pune, India: A Case Study

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Pteropus giganteus (Indian Flying Fox) is a widely distributed megachiropteran that lives in large diurnal roosts numbering several thousand individuals, located on large trees, mostly near a water body. The present study gives an account of the germination studies carried out on seeds from scat and rejecta pellets of the feeding plants of *Pteropus giganteus* around Pune, India. The greatest number of seeds observed in scat and rejecta pellets were of *Ficus benghalensis* and *Ficus glomerulata*. The germination rate of seeds of *Ficus benghalensis* was 86.11% and 71.11% for scat and rejecta pellets respectively, while for *Ficus glomerulata* the rates were 86.11% and 62.22%. The results point towards a better germination of seeds obtained from scat and reject pellet samples than those obtained from ripe fallen fruits of the same species.

Do Chewed Fruit Pellets Discarded Beneath Feeding Night Roosts Reveal Foraging Bat Species?

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While studying the feeding habit of frugivorous bats by the collection and identification of food pellets discarded under the feeding night roost, it is observed that the chewed fruit pellets possess mandibular teeth impression. Measurements of the teeth impression of the pellets were done in a systematic manner. These impressions were compared with the dentition of different bat species found in the study area. The measurements of teeth impression of the pellets include the inter distance between the canine, premolar and molar teeth of mandible as well as distance from canine to premolars, canine to molar and premolars to molars. It is evident from the pellet measurements that two species of megachiropteran bats, *Pteropus giganteus* and *Cynopterus sphinx* commonly visit the foraging ground in the study area. The technique of characterization and measurements of the chewed fruit pellets can be used as a method to identify and survey bats in the foraging ground. It is concluded that the detailed study on the mandibular teeth impression found on chewed fruit pellets can reveal the foraging bat species in any habitat.

Impact of Bat-Plant Interaction in the Forest Restoration of Kalakad Mundanthurai Tiger Reserve, Southern Western Ghats, India

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The available bat diversity (6 Megachiroptera and 29 Microchiroptera) in the forest ecosystem of Kalakad Mundanthurai Tiger Reserve (a part of the southern Western Ghats, India) is important for dispersing seeds, pollinating flowers and controlling insect pests. Three megachiropterans, *Cynopterus sphinx*, *Rousettus leschenaulti*, and *Latidens salimalii*, representing different elevation were selected as study animals for this impact analysis. Identification of plant parts found below secondary roosts, observations from video recording and mist netting in the foraging areas were taken as documentary evidence of fruit bat–plant interdependence. Their species-specific dietary preferences help to retain the community structure and long time survival of specific plant taxa in the forest ecosystem. Similarly the diets of four insectivorous species (*Hipposideros ater*, *Taphozous melanopogon*, *Rhinolophus beddomei*, and *Megaderma* lyra) were studied to assess their dietary impact on pest management and forest ecosystems through fecal pellet analysis. Nonetheless, the persistence of bats in the forest ecosystem remains in question, primarily because of the indiscriminate anthropogenic perturbation in their habitat. Moreover, bats have very poor recognition in India, and Indian legislation and policies can be revised only through species-specific impact analysis.

Aspects of *Tadarida plicata* Research at Yangon University

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This paper presents ongoing research at the University of Yangon on the Southeast Asian Guano Bat, *Tadarida plicata*. Ecological information on the location, description, and use of roosts continues to be compiled using techniques, ranging from semi-structured interviews to searches for new roosts to radio-tracking, to log nightly foraging activity. Specialist techniques in population monitoring have been developed and are being used to monitor key roosts. The ecosystem services provided by this species are being investigated through an intensive dietary analysis study. The economics of the guano traders are also being quantified on a countrywide scale. Further applied research is investigating the value of bat guano as an agricultural fertilizer. Key outputs from these studies will produce the most comprehensive management plan to date for any bat species in Myanmar.

Conservation Status of *Tadarida plicata* in Cambodia

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Large colonies of *Tadarida plicata* have existed in Cambodia for many years, although prior to this study very little was known about the status, economic benefits, or threats to *T. plicata* in Cambodia. As a consequence of the present study, the number of known large colonies has now increased from two to seven with further seasonal roosts being recorded in different parts of the country. Population estimates have been recorded for major roost sites and key ecological data have been collected. The structure and value of the trade in guano has also been assessed and urgent threats have been identified. Guano is collected from cave colonies, and provides livelihood income for rural communities. This presentation highlights our current knowledge on the status of *T. plicata* in Cambodia and provides recommendations for its future conservation.

Habitat Use and Feeding Activity of *Tadarida plicata* in Thailand

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Critical information concerning the economic and ecological importance of insectivorous bats is needed to further their conservation. This study quantified feeding rate and habitat use of *Tadarida plicata* around Khao Chong Phran cave in Ratchaburi Province, central Thailand. The cave contains one of the largest colonies of *T. plicata* in Thailand (estimated as approximately 2.5 million individuals). Bat activity was determined by conducting five-minute spot samples along pre-determined road transects using time expansion bat detectors to determine the species and behavior. Sampling began at sunset and continued for 120 minutes. Habitats were classified around the cave within a radius of 30 km from the karst area into five main groups: rice fields; forest patches; sugarcane fields; urban areas; and others. The proportion of signal-receiving time over the total recording time was calculated to obtain an estimate of the relative activity of bats within each habitat, and the number of feeding buzzes per unit of activity time was used to calculate an index of attack rate by bats. Bat activity was also estimated at each site by calculating the average number of bat passes per minute. MANOVAs were used to examine within-year variation and the effects of recording sessions and habitat types on the variance of the length of bat activity time and the mean number of feeding buzzes emitted by bats. In

addition, differences in mean attack attempt (numbers of feeding buzzes per unit of activity time) between recording sessions, among habitats and among seasons were examined as well as the effect of distance from the cave. The importance of the role that *T. plicata* play in natural and cultivated ecosystems will be discussed.

Roost Diversity of Forest-interior Bat Species in Peninsular Malaysia

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Developing an understanding of roosting behavior and roost availability is important for assessing factors essential for the conservation of bat populations and diversity. Thus this study aims to determine the roost selection of a few selected insectivorous bat species in order to better understand their specific environmental and conservation needs. The study was carried out for 20 months in 2003 and 2004 in the Krau Wildlife Reserve, Peninsular Malaysia. A total of 69 individuals from four selected bat species were radio-tagged and tracked for 488 days to 184 roosts. Results showed that all four species selected different roost characteristics; *Rhinolophus trifoliatus* roosts under foliage (leaves, palms and rattan), *R. sedulus* under loose bark and cavities formed in buttresses of fallen trees, *Kerivoula papillosa* in narrow cavities formed in live, standing trees while *Hipposideros ridleyi* in long, deep hollows formed in the trunk of old, large, fallen trees. From the results, we postulate that habitat changes in intact interior forests can affect bat populations at varying degrees. Species selecting roosts of limited availability and distribution in intact forests, such as the *H. ridleyi*, are expected to face highest risk of extinction in disturbed systems. In contrast, animals selecting roosts that are widely available in all forest conditions (i.e., leaves), such as the foliage roosting *R. trifoliatus,* will be the least at risk. Such preliminary information can contribute profoundly to the drafting of forest management and monitoring plans to enhance the conservation of bat populations.

Spatial Mapping for Foraging Extent and Association of Forest Interior Insectivorous Bats

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Foraging strategies and pressures such as species competition, limited food resources, and niche overlap are among the driving mechanisms to spatial patterning. A study was initiated at the Krau Wildlife Reserve (KWR), Pahang, Malaysia to investigate the foraging extent and interspecific associations through spatial mapping of insectivorous bats in undisturbed rainforest. Of the 33 species from 5,231 individuals of bats trapped in four study sites within KWR namely Lubuk Baung (LB), Kuala Serloh (KS), Kuala Gandah (KG) and Jenderak Selatan (JS), spatial pattern of four selected species [*Hipposideros cervinus* (Hice), *Rhinolophus lepidus (refulgens)* (Rhle(re)), *Kerivoula intermedia* (Kein), and *Kerivoula pellucida* (Kepe)], was analyzed using SADIE (Spatial Analysis by Distance IndicEs) and mapped. The generated map of clustering

indicated that Rhle(re) forages fairly uniformly at JS but captures were clustered into a very large patch of about 0.32 km^2 at LB. In contrast captures of Hice were clustered into small patches of about 0.01 km^2 at KS to 0.18 km^2 extent at LB. The least obvious foraging extent was exhibited by Kepe. This species foraged at very localized and non-contiguous patches at all study sites. When the interspecific foraging extent was mapped through spatial association, a highly antagonistic association was found between Hice and Rhre, and Hice and Kein. The result stressed evolution of spatial compartmentalization of the insectivorous bats as a possible mechanism to avoid competition throughout the study sites.

Echolocation Call Frequency Variation and Genetic Structure

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The origin and maintenance of intraspecific variation in vocal signals is considered important in population divergence and speciation. Where vocalizations are transmitted by vertical cultural inheritance, similarity is expected to reflect co-ancestry, and so vocal divergence should correspond to genetic structure. Rhinolophoid bats are characterized by echolocation calls dominated by a constant frequency (CF), which in *Rhinolophus* is influenced by maternal imprinting. Although CF calls are known to correlate with non-genetic factors, it is not known whether echolocation call frequency relates to genetic structure. I describe two studies undertaken to address this issue. In the first, CF calls of the Formosan lesser horseshoe bat (*Rhinolophus monoceros*) were recorded from across Taiwan. Within regions, pairwise differences in call frequency among individuals correlated strongly with microsatellite-based genetic differentiation. However, large-scale population differences in CF were also detected, and found to be congruent with discontinuities in allele frequencies, resulting from historical events (vicariance). A second study of four co-distributed rhinolophoid species from southeast Indonesia further supports the role of population history in determining call variation. Here, a lack of congruence in the geographical pattern of call variation among taxa appears to result from independent colonization histories. I discuss the importance of these findings in the context of speciation in bats.

The Relationship Between the Proportion of Moths in Diet and Call Frequency of Bats in the Superfamily Rhinolophoidea in Bala Forest, Hala-Bala Wildlife Sanctuary, Narathiwat Province

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The allotonic frequency hypothesis (AFH) states that the incidence of tympanate moths should be higher in the diet of bats whose echolocation calls are dominated by frequencies outside the moths' best hearing range of 20–60 kHz. Support comes from several previous studies, but evidence for the AFH remains controversial for bats in the superfamily Rhinolophoidea (Hipposideridae and Rhinolophidae) whose calls are dominated by single constant frequency (CF) calls. Some prior studies suggested that morphological characteristics,

rather than echolocation call frequency, might limit the range of potential prey items. Most bats in this superfamily that are found in Bala Forest (5° N, 101° E), southern Thailand, use a high frequency of echolocation (> 70 kHz). These bats are usually found in the forest understory where moths are present throughout the year. In the present study, bats were captured from a natural trail and feces collected. Five feces per individual were examined for the ingested insects under a stereoscope. Overall, a very low percentage (by volume) of Lepidoptera was found in their diet (average 2–5%). Generally, a high percentage of Isoptera, Hymenoptera, Coleoptera, and Orthoptera were found in the diet of both bats using high frequency (> 70 kHz) and those using low frequency (< 70 kHz). The significance of the use of high frequencies in these bats is discussed.

Molecular Systematics and the Evolution of High Frequencies within the Genus *Rhinolophus*

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A supermatrix approach, using three nuclear introns and one mitochondrial gene, was used to construct a well-supported phylogeny for the horseshoe bats. This phylogeny was then used to test various hypotheses for the evolution of high frequencies within the genus *Rhinolophus*. High frequencies do not appear to have evolved in response to moth hearing. Although a relationship between frequency and body size occurs in the Rhinolophidae, body size cannot explain the high frequencies used by this family. Furthermore, many species deviate from the allometric relationship, and two hypotheses (the Foraging Habitat Hypothesis and the Acoustic Communication Hypothesis) are tested to explain these deviations.

Variation in the Frequency of the Echolocation Calls of *Craseonycteris thonglongyai* in Thailand and Myanmar

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Recent surveys in Myanmar documented for the first time the presence of the Bumble Bee Bat, *Craseonycteris thonglongyai* outside the Kanchanaburi region in Thailand, doubling its distribution range. Individuals discovered in Myanmar were morphologically indistinguishable from Thai individuals although their echolocation call peak frequency was 8–10 kHz higher. This high difference in echolocation frequency was unusual for populations of the same species that are distant by only 200 km. These findings raised important questions about the possible presence of cryptic species and the validity of echolocation call variation to define species or subspecies boundaries. In April and November 2006, we recorded *Craseonycteris thonglongyai* echolocation calls from different caves throughout its entire known distribution range in Thailand and Myanmar. Differences in echolocation call frequency between colonies were compared with environmental factors and colonies' geographic position. The ability of echolocation calls to reveal population structure, subspecies or cryptic species is also discussed.

Taxonomic Studies of Southeast Asian bats

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Taxonomic studies of mainland Southeast Asian bats began in the 19th Century. The pace of research varied, dependent on the interest of individuals and the idiosyncrasies of world politics. In 1997, the Harrison Institute initiated a series of bat taxonomy projects in Southeast Asia. Initial studies were concentrated on the bat fauna of Vietnam. Three publications (1997–2001) included a checklist of 85 species with more detailed data for 59, of which 13 were new country records. Between 2001 and 2005, three co-authored papers on the bats of Cambodia included 42 species (11 new country records and 1 new to science). Outputs of the Institute's Darwin Initiative project in Myanmar included 9 international papers (2000–2005), with information on 95 species, including 11 new country records and 1 species new to science. More recently, collaborative studies on whole organism taxonomy and echolocation with institutions in Thailand, Vietnam, Cambodia, Lao PDR, and Indonesia have led to three publications, which include nine new country records for Thailand, three for Vietnam, and one new species for Sulawesi. Four MSc students are looking at intra- and interspecific variation in echolocation and the value of acoustic data in identifying cryptic species. Many field surveys have been conducted and a website is being prepared with information on the taxonomy, distribution and ecology of the 155 species of bat currently recorded from the region.

Study on Distribution and Taxonomy of Chinese Horseshoe Bats

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In China, the study of horseshoe bats of the genus *Rhinolophus* began at the end of 18th Century and the early comprehensive work was Allen's book (1938, 1940). Until now this book is still an important reference for studying bats in China. This book reported 10 species of Chinese horseshoe bats, while later studies (1992–2005) reported from 12 to 18 species. In the last five years, three species of horseshoe bats were reported as new records from China: *R. paradoxolophus* (from Guangxi), *Rhinolophus marshalli* (from Guangxi), *Rhinolophus stheno* (from Yunnan). Here we discuss several taxonomic problems in the Chinese horseshoe bats. *Rhinolophus paradoxolophus* and *R. trifoliatus* have been known from only one specimen from China that was lost, and *R. osgoodi* and *R. subbadius* have not been represented by specimens from China; thus, occurrence of these four species in China is doubtful. There were several changes in taxonomic status: *R. rouxii sinicus* was changed to *R. sinicus, R. luctus formosae* to *R. formosae*, and *R. lepidus shortridgei* to *R. shortridgei,* while *R. cornutus* was changed to two separate species—*R. monoceros* and *R. pusillus.* In conclusion, we validate 14 species of horseshoe bats in China: *Rhinolophus macrotis, R. marshalli, R. rex, R. luctus, R. formosae, R. pearsonii, R. yunanensis, R. monoceros, R. pusillus, R. shortridgei, R. sinicus, R. stheno, R. affinis,* and *R. ferrumequinum.*

A Phylogenetic Relationship of *Rhinolophus* and *Hipposideros* in Malaysia Using Partial Mitochondrial DNA Cytochrome *b* Gene Sequences

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A study on the phylogenetic relationship between ten species of *Rhinolophus* and nine species of *Hipposideros* was conducted using specimens from Borneo and Peninsular Malaysia, including representatives from *Megaderma* and *Nycteris* as the outgroups. About a 450bp length of mitochondrial DNA cytochrome *b* (mtDNA cyt *b*) gene was amplified in polymerase chain reaction (PCR), and purified PCR products were subsequently sequenced and aligned. Of the 404 nucleotides position examined, the conserved sites accounted are 56.93% while 39.36% are parsimoniously informative. The phylogenetic tree reconstruction using neighbor-joining and maximum parsimony methods show separation between the two families. However, the intraspecific relationship within *Hipposideros* species is still unresolved. In general, the phylogenetic analysis using partial mtDNA cyt *b* gene is useful to show the genetic relationship between selected microchiroptera in this study.

Genetic and Morphological Species Identifications: A Study of Malaysian Roundleaf Bats (Hipposideridae)

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Approximately 113 bat species have disjunct populations on Borneo and Peninsular Malaysia, which are separated by about 600 km. This geographic isolation may reduce gene flow between populations by enough time for speciation to occur. To assess genetic diversity in these bats, we phylogenetically analyzed sequences (404 bp) of the mitochondrial cytochrome *b* (cyt *b*) gene. Herein, we focus on the Hipposideridae and compare two species (*Hipposideros cervinus* and *H. bicolor*) to estimate intra- and interspecific genetic variation. Within *H. cervinus* we identified eleven haplotypes, separated by < 2% in cyt-*b* variation, indicating that these populations have not been isolated for a sufficient time to speciate. Field identifications of individuals within the *H. cervinus* complex suggested at least two species were present. In contrast to *H. cervinus*, *H. bicolor* were separated by genetic distance values averaging 4–9%, indicating that these populations have been genetically isolated. However, this isolation was not reflected in the external morphology of specimens. Results from the family Hipposideridae indicate that identifying species using only external morphology could result in an over- or underestimation of bat diversity. We propose that genetic data should be used first followed by detailed morphological data to develop greater accuracy of faunal studies.

Molecular Phylogenetics and Biogeography of Bats in the Genus *Hipposideros*

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Paleotropical bats in the genus *Hipposideros* are especially diverse in Southeast Asia. They make a strong contribution to the diversity of the Asian bat communities. Unveiling the factors that have promoted their evolutionary diversification in the area is relevant to understanding the historical dynamics of biodiversity and to devising regional conservation strategies. I have generated a molecular phylogeny based on nucleotide sequences for the mitochondrial gene cytochrome *b*, and the nuclear genes e28vWf and RAG 2, for most species in the genus. The genus originated somewhere in the Old World tropics some 25 mya. It soon colonized the whole region. A most basal split dated 24 mya separates an African endemic clade of large body sized species. The other lineage has a mostly Asian and Australasian history, colonizing Africa only in two further instances. Although the island systems have had little relevance in the diversification of the relatively recent monophyletic radiation of the large body sized bats in the *H. pratti*, *H. armiger*, and *H. diadema* groups, they have played a major role in the evolution of the *H. bicolor* group. Several old lineages originated in Australasia, and the islands of the Sunda shelf had caused some recent speciation in the group.

Taxonomic Status of *Myotis formosus* Complex (Chiroptera: Vespertilionidae) from Taiwan and Adjacent Areas: Inferences from Morphology and Molecular Systematics
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Myotis formosus (Hodgson, 1835), which is widely distributed in South and East Asia, is a brightly colored bat with black particolored wing and interfemoral membrane. The first record of this species in Taiwan was reported by Swinhoe in 1862. Subsequently, two new species, *M. watasei* and *M. flavus*, which are similar to *M. formosus*, were reported from Taiwan. However, the authors considered these two species as synonyms of *M. formosus*. In addition, many *Myotis* with the similar coloration, such as *M. rufoniger*, *M. rufopictus*, and *M. tsuensis*, were treated as synonyms of *M. formosus*, too. Recently, we examined the specimens that were so called "*Myotis formosus*" from Taiwan; however, they could be distinguished into two forms by fur color. To understand the taxonomic status of *Myotis formosus* complex from Taiwan, we used both morphological and molecular systematic methods. The results revealed that *Myotis formosus* complex from Taiwan includes two morphologically and genetically distinct species. One of them has yellow fur, which is similar to *M. flavus*, but the other has conspicuously orange fur and black-edged ears, which is like *M. watasei*. Their dental characters also show significant differences. Moreover, the genetic distance between these two species is about 18%. Comparing to the holotype of *M. formosus* and related species, we considered that the yellow taxon, *M. flavus*, should be *M. formosus flavus* and the orange one, *M. watasei*, should be a subspecies of the valid species, *M. rufoniger*. Finally, we discuss taxonomic status of *Myotis formosus* complex from other areas and infer their phylogeny relationships.

Phylogeography of the Japanese Pipistrelle (*Pipistrellus abramus*)

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The Japanese Pipistrelle, *Pipistrellus abramus*, is often regarded as a subspecies of *P. javanicus*, but is clearly separable. It is widely distributed in Southeast Asia from Siberia to northern Vietnam, Burma, and India. The species lives in man-made structures such as houses, and it is the most common species of the genus in Japan. Its distributional patterns in the Japanese archipelago have been regarded as limited to urban and rural areas in Kyusyu and Honshu islands, apparently absent from undisturbed habitats. Recently, it has been found at the northern and southern areas of Japan, namely Okinawa and Hokkaido. This suggests, among other possibilities, a recent colonization of these areas from different continental regions by either long distance dispersal, or given *P. abramus* synanthropic behavior, by accidental human transportation. Based on distribution, genetic relationships, morphology, and echolocation call frequency, we elucidated that *P. abramus* from Japan is a single phylogeographic group, genetically and phenotypically differentiated across its range. Its origin may be varied, with various routes of colonization from continental mainland into Japan.

Phylogenetic Relationships of Cynopterine Megabats

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The pteropodid subfamily Cynopterinae has complex taxonomic history. As conceived by Andersen (1912), cynopterines were a derived group of short-faced pteropodids that included tube-nosed fruit bats (*Nyctimene*) and African collared bats (*Myonycteris*) as well as a variety of Indomalayan genera. Several studies subsequently suggested that *Myonycteris* belongs elsewhere in the pteropodid tree, and that tube-nosed bats (often placed in a separate subfamily Nyctimeninae) might not form a clade with the remaining cynopterines. Andersen (1912) discussed relationships of the Indomalayan members of the group, but description of a number of new cynopterine genera after Andersen's review left relationships within the group uncertain. As part of a larger project to elucidate relationships within Pteropodidae, we sampled representatives of all putative cynopterine genera to investigate relationships within this group. We sampled 3 nuclear genes (RAG1, RAG2, vWF), four mitochondrial genes (cyt-*b*, 12S, tRNA Valine, 16S), and over 300 morphological characters. Preliminary results indicate that Nyctimeninae and Cynopterinae represent reciprocally monophyletic clades, and that *Myonycteris* groups with African epomophorines. Within Cynopterinae *sensu stricto*, there are two distinct clades, one comprising *Cynopterus* and its allies, the other and eclectic group of taxa including an endemic Philippine clade. Implications of this phylogeny for understanding morphological evolution and historical biogeography will be discussed.

Field Discrimination of *Cynopterus* Species, (Chiroptera: Pteropodidae) *C. sphinx* Vahl, 1797 and *C. brachyotis* Müller, 1838, in Sri Lanka

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In Sri Lanka, it is difficult to differentiate in the field between *Cynopterus sphinx* Vahl, 1797 and *C. brachyotis* Müller, 1838 since these two species of closely related fruit bat are very similar in a range of morphometric characters. The aim of this study was to conduct a comprehensive taxonomic analysis of Sri Lankan *Cynopterus* in order to identify discrete features that can be used to discriminate between the two taxa. Initially, based on a series of 364 adult specimens, a number of external and craniodental characters were investigated. In some cases, individuals of both taxa were found at the same location (sympatric distribution), whilst in others, only one species was found (allopatric distribution). Specimens were assigned to one or other of the species on the basis of a combination of characters, both external and craniodental. It was found that for field identification, the most important features included: shape of the apex of the ear, the extent of whitening at the edges of the ear margins and at the finger bones against wing membrane, and forearm and ear length. The two taxa were significantly different to each other ($p < 0.05$) in each character system derived. The selected morphometric dimensions were consistent with those used in previous studies. *C. sphinx* and *C. brachyotis* in Sri Lanka were redefined using a new set of characters and a taxonomic key was developed.

Phylogenetic Relationships of Harpyionycterine Megabats

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The two species of the megachiropteran genus *Harpyionycteris* exhibit a unique set of craniodental traits. For this reason, the systematic position of *Harpyionycteris* has been controversial, and apparent affinities with *Dobsonia* pointed out early in the systematic history of the group have been disregarded in formal classifications. However, a recent molecular phylogeny showed that a *Dobsonia-Harpyionycteris* clade is indeed well supported. Given that this clade is nested within other megabat groups with typical pteropodid dentition, the multicuspidate pattern of the dentition in *Harpyionycteris* is mapped as a derived feature. In this contribution we explore further the composition of Harpyionycterinae by adding to the character data (now including four genes) and the taxonomic sample within megabats. Parsimony analyses of this expanded dataset confirmed that the New Guinean genus *Aproteles* is a member of this group, and that the Sulawesian genus *Boneia*, previously associated with rousettine megabats, also belongs in the Harpyionycterinae. We discuss the morphological and biogeographical implications of this unexpected finding, and propose a rearrangement of the current megabat classification to accommodate these genera in an expanded Harpyionycterinae.

A Taxonomic Review of *Rhinolophus malayanus* and *R. stheno* (Chiroptera: Rhinolophidae) in Thailand

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Rhinolophus malayanus and *R. stheno* are known as sibling species and are hardly distinguishable morphologically. The acoustic data of both species from recent surveys showed geographic variation in echolocation call frequency among populations in Thailand north and south of the Isthmus of Kra. There are two phonic types of *R. stheno*, one with a peak frequency of 95 kHz to the north of Kra and another of 86 kHz south of Kra. Northern populations are distinctly smaller. Even though the sample size of *R. malayanus* is small, there is no significant difference in morphology between northern and southern populations. However, there are intraspecific variations in echolocation among populations, with 75 kHz from the North to 89 kHz from the South. Additional data were collected from over 25 sites scattered across the country to fill information gaps. Call frequency of captured bats was recorded by Pettersson D240x time expansion bat detector and iRiver iHP-120 digital sound recorder. The external, dental, and cranial morphological characters were measured with a digital caliper. This study is in progress but current data for both *R. malayanus* and *R. stheno* suggest that both taxa may comprise more than one species in Thailand.

A Taxonomic Review of *Rhinolophus pusillus* and *Rhinolophus lepidus* (Chiroptera: Rhinolophidae) in Thailand

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This study is concerned with two species of rhinolophid, *Rhinolophus pusillus* and *R. lepidus*, which have essentially similar external morphology and craniodental measurements. Previous taxonomic studies suggest that their taxonomy is confusing as there are a number of synonyms and a smaller number of subspecies. In the past, taxonomic studies of the two species have been of the classical kind with a qualitative and quantitative review of the external and craniodental morphology. Today, morphometric analysis techniques are more sophisticated and better able to discriminate between taxa. Species identification can also be supported with recordings and analysis of echolocation calls and it has been shown elsewhere that the calls of many bat species are a useful aid to identification at genus and species level. Current information suggests that the constant frequency of echolocation calls of *Rhinolophus lepidus* is 95–105 kHz in Thailand and 100 kHz in Malaysia. The frequency of *Rhinolophus pusillus* is 105–110 kHz. From recent studies, there is a third taxon that is morphologically similar to *R. lepidus* and *R. pusillus* but larger and with a lower frequency of about 85.2–91.6 kHz. It is known from Pho Soun Sai National Park, Loei province in Northeast Thailand. There is also another taxon that is smaller than *R. pusillus* with a higher frequency of about 126.3 kHz, known from Khao Samohkhon, Lopburi province in Central Thailand. The current study aims to answer the question of how many species in the *R. pusillus* group are present in Thailand and highlight key locations for conservation.

A Taxonomic Review of *Hipposideros ater, H. cineraceus,* and *H. halophyllus* (Chiroptera: Hipposideridae) in Thailand and Lao PDR

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In the *Hipposideros bicolor* group in Thailand, there are three species that are very similar in shape of the noseleaf, size of external and cranial characters, morphology and echolocation calls. They are *H. ater, H. cineraceus,* and *H. halophyllus.* The latter species is also very similar to the Lao endemic *H. khaokhouayensis* in the structure of its noseleaf and echolocation. According to Corbet and Hill (1992), *H. ater* and *H. cineraceus* overlap in their distribution in many parts of Thailand. However, Hill (1975) and Hill and Yenbutra (1984) found that *H. ater* specimens previously collected and identified in Thailand were actually referable to *H. halophyllus*. Yenbutra and Felten (1986) considered that *H. ater* was only known from one locality, Khao Bin Cave in western Thailand. Clearly, there is much taxonomic confusion. It is therefore proposed to ask three questions: (1) does *H. ater* occur in Thailand? (2) what are the diagnostic characters of the three species? and (3) does the considerable geographic variation in the morphometrics and echolocation calls shown by *H. cineraceus* and *H. ater* suggest that there are additional, currently unrecognized sibling species present?

Diversification in Philippine *Rhinolophus* Bats: Cryptic Variation in an Oceanic Archipelago

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Diversity in the Philippine archipelago has been strongly influenced by both colonization of islands and *in situ* speciation. In contrast to much of the mammalian fauna, relatively little is known about the processes of colonization and diversification for most bats of the Philippines. Recent collections include two forms of the arcuate horseshoe bat, *Rhinolophus arcuatus*, which are broadly sympatric throughout the archipelago. Cryptic diversity within islands is confounded by variation across islands and has made conclusions hard to reach. DNA sequences from the mitochondrial genome show two genetically divergent lineages that correspond to “wide” and “narrow” morphotypes based on characters of the noseleaf. Phylogeographic patterns vary between these lineages and are discussed with regard to two competing hypotheses. Geographic isolation and allopatry explain much of the data in the “narrow” lineage; however, a very close relationship with *R. inops* also is indicated. An alternative hypothesis of ecological divergence is discussed for these data and Southeast Asian horseshoe bats more generally.

The Preliminary Study of Geographic Variation in Echolocation Call and Morphology of *Rhinolophus affinis* (Chiroptera: Rhinolophidae) in Thailand
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Thailand supports an extremely diverse fauna and flora. Situated in the Indo-Chinese peninsula of the Oriental region, the country has been described as a 'zoogeographical cross roads', which links the biotas of the Sino-Himalayan, Indo-Burmese, Indo-Chinese, and Sundaic regions. This diversity is reflected in the bat fauna, with over 120 species recorded from the country. In this particular project, one widely distributed rhinolophid, *Rhinolophus affinis* was selected for study because its taxonomic status is in need of revision and its relationship with a sibling species, *R. rouxii*, found elsewhere in southern SE Asia, is unclear. The morphometric characters currently employed to discriminate between the two taxa are unsatisfactory and in southern Myanmar specimens were collected recently that shared external and cranial characters with both *R. affinis* and R. *rouxii*. Furthermore, within Thailand, geographical variation between populations of *R. affinis*, especially when measured in terms of echolocation call variability suggests that there may be one or more taxa included within a superspecies currently described as *R. affinis.*

Echolocation of *Rhinolophus malayanus* in Thailand: A Genetic Relationship Approach
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Horseshoe bats (genus *Rhinolophus*) are among the more common bats of the Old World and are distributed throughout Southeast Asia, including Thailand. Like other species in the genus, *Rhinolophus malayanus* emit constant-frequency (CF) echolocation calls with a dominant frequency characteristic of the species. However, recent studies revealed that the frequency of *Rhinolophus malayanus* calls shows some variation across the species range, although there is no clear geographic pattern. This leads to the question: are these differences the result of adaptation due to geographical variation or a consequence of genetic barriers resulting from incipient speciation? To understand the possible effects of geographic barriers and/or genetic barriers on echolocation, the phylogeography of this species in Thailand will be studied using genetic markers including the cytochrome *b* gene and microsatellite DNA. This study hopes to gain a greater understanding of this kind of adaptation in a particular *Rhinolophus* species.

Intra- and Interspecific Variation in Morphology and Echolocation in *Hipposideros larvatus* (Horsfield, 1823) in Vietnam

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In the past, the intermediate leaf-nosed bat (*Hipposideros larvatus*) was commonly considered to be an abundant and widespread species in Asia with a geographical distribution that extended from northeast India to eastern Indonesia. However, recent studies in the west and east of its range suggest that *H. larvatus* actually comprises a series of cryptic species, although, in some cases, the limits and validity of these taxa remain uncertain. In Vietnam, research suggests that there are differences in the acoustic parameters of *H. larvatus* occurring in different areas of the country. Previous morphometric studies noted that there was a small form of the taxon found in the north of the country and a larger one to the south. In this current study, the non-geographical and geographical variation of *H. larvatus* in Vietnam will be studied using both morphometric and echolocation characters. The results will be discussed in terms of their taxonomic significance and an attempt made to determine if further cryptic species are present.

Evolutionary Dynamics of Hipposiderid Bats in the Indian Subcontinent

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We made an attempt to identify the level of genetic diversity between the microchiropteran bats *Hipposideros speoris* and *Hipposideros fulvus* from the southern part of India. Both species are morphologically different, sharing the same roosting places and foraging grounds, and is co-distributed in the Indian subcontinent. Both the 16S rRNA data sets were combined, providing 481 bp of aligned sequence for phylogenetic analyses. Sequence divergence of 3.4% was observed within *H. speoris* and 1.4% within *H. fulvus*. The overall nucleotide divergence between species was 33.14%, a level comparable to other groups in the Chiroptera. The empirical base frequency composition of 16S rRNA (A = 0.310, T = 0.243, G = 0.208, C = 0.239) and the transition-tranversion ratio is 0.2764. The level of divergence is comparable with intraspecific variation within other mammalian species.

Systematics of *Pipistrellus* (Chiroptera: Vespertilionidae) from Taiwan: Karyotypical, Bacular, and Morphological Studies

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The genus *Pipistrellus*, with 31 recognized species, is widely distributed around the world. However, since these bats are very conservative in morphological characters, distinguishing different species by external morphology alone is often difficult. Also, their taxonomy remains controversial. Based on the reported karyotypes of *Pipistrellus*, variations in the diploid chromosome number (2n) range from 26 to 44, and fundamental numbers (FN) are from 44 to

60. Moreover, although substantial karyotypical variations are found among species, there is little or no variation at the intraspecific level. The chromosomal characterization seems to be a useful tool in species identification for this genus. In addition, the baculum is also a good characteristic to distinguish *Pipistrellus* species. In the present study, we investigate karyotypes and bacula of *Pipistrellus* from Taiwan. Furthermore, morphological variations of external and cranial characters were analyzed using univariate and multivariate statistics analyses. One hundred and forty-four *Pipistrellus* bats were obtained from Taiwan. According to 38 karyotyped specimens, three groups are recognized by distinct karyotypes: *Pipistrellus abramus* (2n = 26, FN = 44; n = 13); group 1 (2n = 42, FN = 52; n = 14); group 2 (2n = 32, FN = 48; n = 11). Comparing the bacula with eight other species, these two groups have unique shapes, and differ in length (group 1 average is 4.61 mm, and group 2 is 5.24 mm). The statistical analysis of external and cranial characters also support that these two groups were significantly different from other *Pipistrellus*. Therefore, we suggest that these two groups should be two new species. Finally, we provide further information on the distribution, ecology, and life history of the genus *Pipistrellus* in Taiwan.

The Utility of Microsatellite Markers in the Preliminary Study of the Genus *Cynopterus* in Peninsular Malaysia, Sabah and Sarawak Regions

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Cynopterus is one of the most widely distributed bat genera in the Indo-Malayan region. Recent studies using mitochondrial DNA data suggest that there is a cryptic species within *C. brachyotis* in Peninsular Malaysia up to southern Thailand. Based on these studies, forearm length is the only external morphological measurement that can be used to differentiate *C. brachyotis* and the cryptic species. In this study, *C. brachyotis* and *C. horsfieldii* in Borneo were included and examined using four selected existing microsatellite markers. However, in this preliminary study only basic information derived from the microsatellite data of *C. brachyotis* (with its cryptic species), *C. sphinx*, and *C. horsfieldii* were produced. With further study, the generated results might elucidate species boundaries and phylogenetic relationships of the genus *Cynopterus.*

Molecular Phylogenetics of Bats of the Subfamily Murininae (Chiroptera: Vespertilionidae)

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Bats of the subfamily Murininae were grouped traditionally into several supraspecific taxa at various levels based on variation in their dental characters. In this study, we constructed phylogenetic networks of 30 individuals, representing 14 species of the subfamily Murininae and 10 other species of the family Vespertilionidae, based on their sequences of mitochondrial cytochrome *b* and ND1 genes. Our results showed a monophyly of Murininae when rooted with *Chalinolobus tuberculatus*. However, relationships among most species within this clade could hardly be confirmed, including those representatives of putative supraspecific taxa *Harpiocephalus*, *Harpiola*, and *Murina*. More data are essential for understanding mechanisms leading to the low resolution among taxa beneath the subfamily level. On the other hand, the well-supported clades within Murininae clearly disputed the hypothesis of monophyly of either *M. suilla* group or *M. cyclotis* group. We also noticed that individuals that were referred to as *Murina cyclotis*, a species with a broad distribution over Southeast Asia, do not form a monophyletic group and suggested re-assessments of contents and status of this species and its associated forms.

Phylogenetic Relationships of *Kerivoula* Species from Peninsular Malaysia

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The tropical rainforest of Malaysia is one of the most species-rich for bats in the world. Bat communities here are dominated by insectivorous taxa adapted to foraging in cluttered environments. These include bats of the subfamily Kerivoulinae, which consists of two genera (*Kerivoula* and *Phoniscus*). The aim of the study is to investigate the phylogenetic relationships of four Kerivoulinae species (*Kerivoula intermedia*, *K. hardwickii*, *K. pellucida*, and *K. papillosa*) detected in the Krau Wildlife Reserve. Mitochondrial cytochrome *b* DNA sequence data were used to infer the phylogenetic relationships. Both neighbor-joining (NJ) and maximum parsimony (MP) trees indicate that the four *Kerivoula* species are forming independent clades. *K. intermedia* is the earliest to split from the ingroup in the NJ tree, followed by *K. pellucida*, *K. hardwickii*, and *K. papillosa*. Conversely, a MP strict consensus tree was paraphyletic for *K. pellucida*, *K. hardwickii*, and *K. papillosa*. The molecular maternal lineages of the Kerivoulinae generally support the morphological classification of the bats. More species and genes will be added, and the taxonomic resolution issues raised await assessment based on combined analyses of molecular and morphological data.

Population Genetic Structure and Phylogeographic Studies of *Kerivoula* (Vespertilionidae) in Taiwan: Inferences from Mitochondrial DNA

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The Taiwanese Woolly Bat (*Kerivoula* sp.) was found recently in Taiwan. Most individuals have been captured in bamboo forests or nearby habitats. However, this kind of habitat is discontinuously distributed, and most bamboo forests distribute at elevations between 0~2000 m and dominate at elevations between 500~1500 m in Taiwan. To understand the phylogeographic structure of the Taiwanese Woolly Bat and the influences of habitat fragmentation, we examined variation in the complete sequence of mitochondrial DNA cytochrome *b* gene. Forty-eight specimens from 18 localities were sequenced, and 13 haplotypes were found. Phylogenetic analysis revealed that Taiwanese woolly bats were divided into two genetic clades (clade 1 and clade 2) and the genetic distance between these two clades is 0.0188. The specimens of clade 1 mainly distributed in northern Taiwan, and most specimens of clade 2 were limited to southern

Taiwan. However, there were not significant geographic boundaries between them. In addition, the results of mismatch distribution analysis implied that populations of Taiwanese woolly bats were re-contacted. Moreover, gene flow among regions (northern, central, and southern) differed, with the southern region exhibiting lower gene flow than others. The pairwise genetic distances between populations of Taiwanese woolly bats were relative to geographic distances. Therefore, gene flow in this species seems to be restricted. Finally, we provide explanations for this phylogeographic pattern and some problems for future study.

Characterization of the Roosting Sites of the Golden-crowned Flying Fox (*Acerodon jubatus*) and Philippine Giant Fruit Bat (*Pteropus vampyrus*) and Their Effects on Dipterocarp Forests

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Large fruit bats, *Pteropus vampyrus* in particular, commonly roost tightly packed together on trees, and this crowding often results in noticeable defoliation of roost trees. In the Philippines, White Lauan (*Shorea contorta*) is a common emergent tree in the canopies of native forests and, as such, a popular bat roosting tree. Many dead White Lauan can be found at the fruit bat roost in Subic Bay, and we hypothesized that these were killed as a result of disturbance from the bats roosting in them. We compared White Lauan in and outside of the bat roost area using physical observation and soil physicochemical analysis. We found no significant difference on the soil nutrients between roosting and non-roosting sites, suggesting that bat droppings were not killing White Lauan. Vegetation structure of trees in the bat roost area, however, is significantly different than tree structure in non-roost areas, suggesting defoliation is leading to White Lauan mortality. That bat colonies may eventually kill their own roost trees presents a challenge to conservation management when suitable roost trees are limited. We recommend that protective management efforts for bat roost sites consider protecting a larger number of trees than are actually being used to support long-term occupation.

Current Status and Conservation of the Ryukyu Flying Fox, *Pteropus dasymallus*, in the Ryukyu Archipelago, Japan

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The Ryukyu Flying Fox, *Pteropus dasymallus*, is a medium-sized megabat endemic to Taiwan and the Ryukyu archipelago of Japan and occurs in the northern limit of the distribution of Pteropodidae. This species is listed as endangered in the IUCN Red List 2006. *Pteropus dasymallus* is divided into five subspecies living in the different island groups. Here, we report the current status of three subspecies in Japan—the Orii's Flying Fox (*P. d. inopinatus*), the Daito Flying Fox (*P. d. daitonensis*), and the Yaeyama Flying Fox (*P. d. yayeyamae*)—based on our field surveys. Orii's Flying Fox inhabits Okinawa-jima Island and surrounding small islets. The population size of this subspecies is considered to be the largest among the five subspecies. The population probably increased and extended to an urban area because many planted trees were available as food resources. The Daito Flying Fox inhabits only two small islands of the Daito Islands. The population size of this subspecies was estimated to be about 310–360 individuals, and might have recovered from a critical situation caused by human settlement and heavy deforestation in 1900. Yaeyama Flying Fox inhabits Yaeyama Islands and Miyako Islands. The distribution of this subspecies also may have expanded because this subspecies was not observed on Miyako-Islands (excluding Tarama-jima Island) several decades ago, although the population trend is not clear. There are some conservation problems such as habitat loss by land development, culling as an agricultural pest, predation by introduced carnivores, accidental death caused by exotic palm trees, and food shortage by typhoons.

The Role of the Ryukyu Flying Fox, *Pteropus dasymallus*, as a Seed Dispersal Agent on Okinawa-jima Island, the Ryukyu Archipelago, Japan

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Fruit bats are known as an important seed dispersal agent in tropical ecosystems. Particularly, flying foxes are likely to play a keystone role in the maintenance and regeneration of forest communities of Okinawa-jima Island, where large frugivores are few. However, prior to this study, the interaction between the Ryukyu Flying Fox, *Pteropus dasymallus*, and plants of Okinawa-jima Island was unknown. Here we examined the role of the *P. dasymallus* as a seed dispersal agent by radio-tracking and seed germination experiments. The Ryukyu Flying Fox fed on sixteen native plant species, and the seeds of the fruits they consumed were dropped beneath fruiting tree as pellets and feces. Some fruits of three plant species, *Ficus bengutensis*, *Actinidia rufa*, and *Terminalia catappa,* were carried to feeding roosts near the feeding tree by mouth. Ten plant species with small-seeded fruits (mostly *Ficus* spp.) were carried to other places through the digestive tract. We estimated the potential dispersal distance of seeds as about three kilometers from a source tree based on the night home range size. The maximum dispersal distance of mouth-carried fruits was 126 m for *Terminalia catappa* and the mean dispersal distance for ingested seeds was estimated as 397 m based on flight speed, digestive time, and foraging pattern. We estimated the number of dispersed seeds for some species to evaluate the effect of Ryukyu Flying Fox as a seed dispersal agent. Additionally, germination percentages of some plants were higher after flying fox consumption of the fruits than untouched fruits from trees. These results suggested that the Ryukyu Flying Fox had a positive effect on at least 16 native plants in Okinawa-jima Island, and they play a unique role as a long-distance disperser of *Ficus* spp. and a limited carrier of large-fruits.

Survey on the Short-nosed Fruit Bat (*Cynopterus sphinx*) in Urban Areas of Hong Kong

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The Short-nosed Fruit Bat (*Cynopterus sphinx*) was believed to have a restricted distribution and a declining population size in both Hong Kong and in Mainland China. In order to understand the recent status of *C. sphinx* in the urban areas of Hong Kong, potential roosting sites under the modified fronds of the Chinese Fan-palm (*Livistona chinensis*) and the Petticoat Palm (*Washingtonia robusta*) were searched systematically since April 2004. Over 3,000 *L. chinensis* were surveyed from 476 sites in the urban areas of Hong Kong. A total of 819 individuals of *C. sphinx* and 177 roosts were recorded during the study period. Most bat roosts (86.8%) were found in relatively young trees of 5–10 m in height. Colony sizes ranged from 1 to

28, and 83.1% of individuals were found to roost in harems. This study indicated that *C. sphinx* is commonly found and widely distributed in the urban areas of Hong Kong where human disturbance is omnipresent. This suggests that the species can tolerate humans in the vicinity of their roost.

The Role of Habitat in the Conservation and Management of Flying Foxes in Eastern Australia

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In Australia flying foxes (*Pteropus* spp.) forage at night, primarily on eucalypt blossom, and roost during the day in large communal camps usually in dense, riparian vegetation. The Grey-headed Flying Fox (*Pteropus poliocephalus*) and Black Flying Fox (*P. alecto*) are listed as threatened in New South Wales under the Threatened Species Conservation Act 1995. The Grey-headed Flying Fox is listed nationally as a vulnerable species and is endemic to coastal eastern Australia. Whilst legislative protection is aimed at aiding the conservation of flying foxes, it has not resolved many of the human conflicts with these animals. Managing flying foxes has become an increasing challenge for organizations responsible for wildlife and communities along the east coast of Australia. Conflict is arising between humans and flying foxes as a result of flying fox campsites being located adjacent to, or within, urban and peri-urban areas. In many cases where conflict arises in urban areas, members of the public immediately propose that the camp should be relocated. This study proposes to track flying foxes (*P. poliocephalus* and *P. alecto*) using satellite/ GPS telemetry under two conditions: (a) 'normal' situations and (b) in cases where camps are to be relocated by third parties. This poster describes the study that proposes to identify detailed spatial and temporal movements of the species and assess the availability, usage, and characteristics of both roosting and foraging habitat. Greater knowledge of the reasons why *P. poliocephalus* and *P. alecto* choose particular areas as a roost and detailed information on their movements would assist the management and conservation of these vulnerable species and their habitats, especially in areas where campsites are in close proximity to residential areas, or future residential sites. It is also expected that the data will reveal the locations of previously unknown campsites in more remote locations; these data are keenly sought by management agencies to help plan the conservation of the species.

Transmigrating Pteropids: International Movements of Flying Foxes—Implications for Conservation and Introduction Of Disease

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Human activities appear to be causing significant changes in flying fox distribution and behavior, bringing them into closer contact with domestic animals and people. Flying foxes are reservoir hosts for several recently emerged fatal zoonoses including Nipah virus (NiV), Hendra virus, and Australian bat lyssavirus. NiV is exotic to Australia but present in southern and southeast Asia. The level of contact among flying fox populations in Australia, New Guinea, and

Southeast Asia is currently unknown. The aim of this study was to track the long-distance movements of flying foxes in Australia's border regions as part of a broader project to assess the risk of the introduction of NiV to Australia via flying foxes. Satellite transmitters were placed on eight flying foxes (four *Pteropus alecto*, two *P. vampyrus* and two *P. neohibernicus*) and their movements were tracked for a total of 156 weeks. Ten movements across political and putative ecological boundaries were made by the flying foxes. *P. alecto* moved between Australia and Papua New Guinea on four occasions, and between Papua New Guinea and Indonesian Papua on five occasions. *P. vampyrus* moved from Timor-Leste to Indonesian West Timor on one occasion. *P. alecto* and *P. neohibernicus* were captured at the same roost site and exhibited very different movement patterns. *P. alecto* was shown to roost and feed close to a major urban center (Merauke) despite the presence of large areas of natural forest in the surrounding region. These results suggest a contiguous population of *P. alecto* exists in parts of north Queensland, Western Province (PNG), and Papua (Indonesia). This highlights the potential for close connectivity between flying fox populations on the Australian and New Guinean landmasses and associated political regions and hence the importance of international cooperation in disease risk management and conservation planning.

Bat Diversity and Conservation in Taiwan

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Although the total land area of Taiwan is about 35,800 square kilometers, it has one of the highest bat diversities in the world. So far, two species of megabats and more than 30 species of microbats have been recorded, and the list is still expanding, with new species of bats being found in Taiwan and its offshore islands. To promote bat research, conversation, and education in Taiwan, the Bat Association of Taiwan (BAT) was founded in March 2004. Since then, BAT has conducted regular surveys of bats in Taiwan and its offshore islands; held local and international symposia, workshops, training courses and other educational activities; produced brochures, pamphlets and handbooks on bat ecology and conservation; and published a monthly e-paper, as well as quarterly magazines to help people understand and appreciate bats and their important roles in ecological services. BAT also tries to integrate the cultural aspect of bats into their conservation by relating true bats with images of bats in Chinese paintings, sculptures, furniture, decorations, temples, historic monuments, etc., so that people are inspired to appreciate bats as a true sign of good fortune. For more information of BAT and its work, please check its website at: http://www.bats.org.tw.

Baseline Survey of the Bats of Hong Kong

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Effectively wildlife conservation relies on gathering baseline information to identify changes over time in the populations of concern. However, the historical data in Hong Kong are insufficient to serve as a baseline against which population changes over time can be assessed. In view of this, in 2002 the Agriculture, Fisheries and Conservation Department, HKSAR launched a long-term program of monitoring mammals. Three different kinds of survey methods are used for studying bats in Hong Kong: direct counting at their roost sites, capture study using mist nets and harp traps, and detection of echolocation calls. Twenty-two species of bats were recorded during recent surveys, including three new to Hong Kong—*Myotis muricola*, *Tylonycteris robustula*, and *Pipistrellus tenuis*—and one new to science, *Pipistrellus hongkongensis*. Among them, *Hypsugo pulveratus*, *P. hongkongensis*, *M. muricola*, *M. horsfieldii*, and *T. robustula* were identified as species of conservation concern.

Roost Survey of Cave-dwelling Bats in Yangmingshan National Park, Northern Taiwan
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The Yangmingshan National Park has preserved large areas of natural vegetation and numerous caves suitable for bat inhabitation in Northern Taiwan. A survey of cave-dwelling bats in and around the park was conducted from late March to mid-November in 2006. Potential roosting sites visited included caves, abandoned mines and buildings, water tunnels, draining culverts, bridges, rock cleavages, and shelters. Several roost characteristics and the condition of bats were recorded. Bats and bat pellets were found in 41 of 85 sites visited. Of the roost sites, 26 (63.4%) were rock caves, 12 were buildings (29.3%), 2 were water tunnels (4.8%), and 1 was an abandoned bomb shelter (2.4%). Five species belonging to three families and four genera were recorded, and a new record of *Myotis* sp.1 was confirmed in the survey area. The Formosan Leaf-nosed Bat (*Hipposideros armiger*) and the Formosan Lesser Horseshoe Bat (*Rhinolophus monoceros*) were the most common cave-dwelling bat species in Yangmingshan. The Formosan Greater Horseshoe Bat (*Rhinolophus formosae*) was less common, but 18 day-roosts of this species were found in this survey. This is the first time that so many roosts of this solitary species have been recorded in one area in Taiwan.

Distribution and Population Status of *Craseonycteris thonglongyai* in Thailand
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Craseonycteris thonglongyai (Kitti's Hog-nosed Bat), one of the smallest mammals in the world, is a cave-dwelling bat distributed in the confined area of limestone ranges in Thailand and limestone outcrops in Myanmar. In Thailand, this species was first discovered in 1974, and appeared restricted to a limited number of caves located along Kwae Noi River in Sai Yok District. More recently, their range has been extended to the central and western parts of Kanchanaburi Province. Potential factors that may limit the distribution of this species include unsuitable climate conditions and the availability of roost caves. Three population censuses and monitoring exercises were conducted in Thailand in 1983–84, 1997, and 2004. The results showed that the total population of this bat increased from approximately 2,000 (21 caves) to 2,600 (22 caves), and to 5,000 (35 caves) individuals, respectively, due to the discovery of new roost caves in the expanded study area. However, when analysis was restricted to cave roosts that were previously surveyed, the same estimation methods found that between 1984–1997 (15 caves) the population decreased by around 10%, and between 1997–2004 (11 caves) by around 14%. This illustrates the importance of repeat sampling at the same caves for accurate monitoring of long-term population trends, and demonstrates that, despite discoveries of new cave roost populations, the future of *C. thonglongyai* in Thailand remains uncertain.

Understanding the Winter Ecology of a Long Distance Migratory Bat, *Vespertilio sinensis*, from Scattered Data: Preliminary Results

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The Asian Particolored Bat, *Vespertilio sinensis*, is distributed across East Asia, from Taiwan through eastern China and Siberia to the Korean Peninsula and Japan. Maternity roosts of this species, usually in the order of thousands of individuals, have been the focus of several studies. However, males are rare members of these colonies and therefore almost nothing is known about their particular life history. The winter ecology of the species is also practically unknown. In Japan, bat recapture records at the few winter roosts found across the country, indicate that this species migrates seasonally hundreds of kilometers (200–800 km). During the past seven years, a winter colony of this species in Miyagi Prefecture, northern Japan, has been monitored, bringing the opportunity to pool together data on male and female bats' roosting ecology during winter. Our preliminary results suggest that both male and female bats use several roosts during winter, probably associated with their seasonal migration. Multiple recaptures of the same individuals across years also suggest winter roost fidelity. In general, females were heavier and larger than males, and body weight changes during winter suggest little activity during the season. The scattered nature of our data limits their interpretation. However, the data give clues into aspects of this species' previously unknown winter ecology, and highlights the need for a more comprehensive monitoring strategy for this elusive species.

Relationships Between Echolocation Frequency and Body Size in Five Species of Vietnamese Hipposiderid Bats

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There is general consensus that a negative correlation exists between body size and echolocation call frequency of maximum energy in at least five families of bats. To examine whether this is true for Vietnamese members of the Hipposideridae family, field surveys were undertaken at Kim Hy Nature Reserve in northeast Vietnam in 2006–2007. Kim Hy Nature Reserve encompasses roughly 150 km^2 of karst forest and contains numerous cave systems. Results are presented for five species (*Hipposideros cineraceus*, *H. pomona*, *H. larvatus*, *H. lylei*, and *H. armiger*), which collectively span the full range of body sizes reported for hipposiderid bats in Vietnam. These concur with previous studies and confirm that frequency of maximum energy scales negatively with body size among Vietnamese representatives of *Hipposideros* genus. While little is known about the natural history of Vietnamese bats, relationships between morphology, echolocation call design, and foraging strategy are increasingly understood within chiropterans as a group. Such research provides an important means of assessing ecological preferences of Vietnamese bat species and prioritizing

conservation efforts at a time when the country's natural habitats are increasingly degraded by modern development.

Acoustic Study of Bat Species Diversity and Feeding Intensity in Intact Forest and Rubber Plantations

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Generally, large areas of tropical rain forest in Southeast Asia have been replaced by rubber plantations. However, only a few studies have been carried out to determine the effect of rubber plantations on biodiversity loss. As there are growing concerns on the loss of biodiversity, reliable data on suitable land management practices for wildlife conservation, including bats, are needed. Conservation of insectivorous bats should be based on protecting their foraging habitats and their roosts. However, no information on the impact of habitat disturbance from large rubber plantations on bat populations is available. Thus, the objective of this study is to compare bat diversity, bat activity, and feeding intensity, based on acoustic techniques, between intact forest and nearby rubber plantations. The study will be conducted in and around the Ton Nga Chang Wildlife Sanctuary (Songkhla Province) and Khao Ban That Wildlife Sanctuary (Trang Province), Southern Thailand. The bat diversity in rubber plantations will be compared to that in intact forest. The results will be explained in terms of wing morphology, echolocation call design, and food availability. These results will be used to identify and predict bat species that are likely to be seriously effected by deforestation, and to identify and protect areas important for bat conservation.

Variations in the Epithelial Cords of the Ovaries of a Microchiropteran Bat, *Hipposideros speoris* (Schneider) During Reproductive Cycle—An Enzymatic Approach

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The ovaries of *Hipposideros speoris* were studied histologically and histochemically for the enzymes, 3β-hydroxysteriod dehydrogenase (3β-HSDH) and succinic dehydrogenase (SDH), and lipid from July 2004–2005. The interstitial cells or so called "epithelial cords" showed variations in their distribution, morphology, enzymity, and their association with other ovarian structures. These cords appear to be formed in the ovarian cortex by the transformation of granulosa of the primordial follicles and small preantral follicles whose ova regress and disappear. Mostly these cords were conspicuous, hypertrophied, and abundant, and in clusters or zones occupying a major portion of the cortex during 4–5 months of gestation and also during lactation. Both histological and histochemical studies revealed their significance as steroidogenic cells. The frequency with which these structures were observed during pregnancy made it obligatory to conclude that they have a certain significant role in ovarian physiology.

List of Participants for the First International Southeast Asian Bat Conference

Phuket, Thailand, 7–10 May 2007

Names and contact information of those attending the SEABC are listed below. Please note that the names are not necessarily listed in alphabetical order by surname. Given the many different countries represented at the conference and the inconsistencies across countries with regards to the order of listing given (first) names versus surnames (family names), it was not always possible for the conference organizers to determine which was the family name and which was the first name. Therefore, names of participants are organized by the first letter of whatever name was listed first on the registration form, and except for making changes in formatting, the Editor (Margaret Griffiths) has left the list as received.

Margaret Griffiths once again thanks the conference organizers—Chutamas Satasook, Tigga Kingston, and Paul Bates, and especially Tigga—for providing the list of bat researchers who attended the SEABC and their contact information.

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ANNOUNCEMENT

2008 BCI Student Research Scholarships

Bat Conservation International announces that applications for 2008 BCI Student Research Scholarships are now available. Research projects should be focused on the roles bats play in providing ecosystem services (such as pollination, seed dispersal, pest control, or maintenance of biodiversity) and/or on habitat requirements that are critical to conservation. Scholarships are competitive. The deadline for applications is **December 15, 2007**. For more information or to apply, visit BCI's website at: **http://www.batcon.org/bcigrants/scholarintro.asp** or contact Bob Locke at **grants@batcon.org**.

FUTURE MEETINGS and EVENTS

17–20 October 2007
A symposium entitled "Fossils, Molecules and Morphology—Evolutionary History of Bats" will be held during the 67th Annual Society of Vertebrate Paleontology (SVP) Meeting in Austin, Texas. The symposium will focus on morphological and molecular methods as they apply to studying the evolution of bats, and will include presentations by bat specialists from Europe, Australia, South America, and North America. For more information about the symposium and the SVP meetings, please check the website at: **http://www.vertpaleo.org/symposia_topics.htm**

18–22 August 2008
XIth European Bat Research Symposium (EBRS) will be held in Cluj-Napoca, Romania. For information about the meeting, please see the EBRS Web site: **http://www.ebrs2008.org/** or contact the organizers at: **ebrs@aplr.ro**

22–25 October 2008
The 38th Annual North American Symposium on Bat Research (NASBR) will be held in Scranton, Pennsylvania. For information, please see the NASBR Web site: **http://www.nasbr.org/**

4–7 November 2009
The 39th Annual NASBR will be held in Portland, Oregon. Please see the NASBR Web site for information.

August 2011
XIIth European Bat Research Symposium will be held in Lithuania.

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Northern Yellow Bat, *Lasiurus intermedius*, by Fiona A. Reid. This attractive bat has yellowish fur, which sometimes has a grayish hue, and the thick yellow fur continues approximately halfway down the length of the tail membrane. The ears are pinkish with a broad, curved tragus. From: A Field Guide to the Mammals of North America north of Mexico, by Fiona A. Reid. 2006. Houghton Mifflin Co., Boston. Illustrations copyright Fiona A. Reid 2006 (reproduced with permission from the artist).

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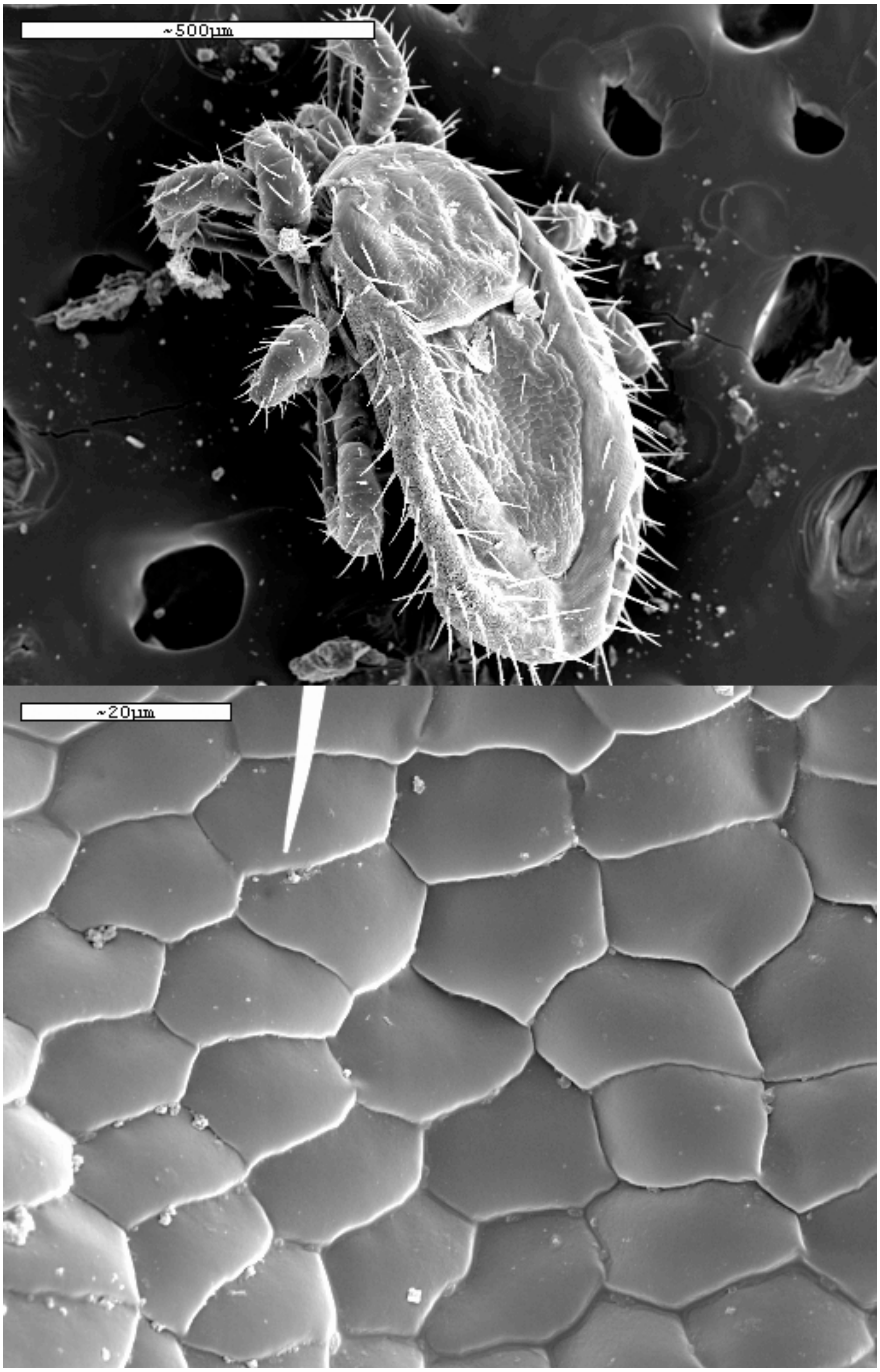

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Bat Research News is published four times each year, consisting of one volume of four issues. *Bat Research News* publishes short feature articles and general interest notes that are reviewed by at least two scholars in that field. *Bat Research News* also includes abstracts of presentations at bat conferences around the world, letters to the editors, news submitted by our readers, notices and requests, and announcements of future bat conferences worldwide. In addition, *Bat Research News* provides a listing of recent bat-related articles that were published in English. *Bat Research News* is abstracted in several databases (e.g., BIOSIS).

Communications concerning feature articles and “Letters to the Editor” should be addressed to Al Kurta, conservation items to Pat Morton, and all other correspondence including recent literature items to Margaret Griffiths. (Contact information is listed above.)

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From the Editor

Dear Subscribers,

Happy holidays! I hope you and your families had a safe and peaceful holiday.

It is once again time for subscription renewals! Production costs of *Bat Research News* have increased this year, which means, unfortunately, that after four years of steady, unchanging subscription rates, there is a slight increase in the 2008 volume-year rates. You should be receiving a renewal notice very soon, if you have not already. In order to keep subscription rates as low as possible, reminder notices will be sent via e-mail whenever possible (or at least the first and second "friendly reminders" will be!). It would be most helpful if you would kindly set your e-mail filters to allow messages through from me (griffm@lycoming.edu). If I do not have an e-mail address listed for you, I will, of course, send your notice via the post.

If you do not receive a renewal notice soon (and think you should have received one), please let me know. Also please do not hesitate to contact me if you have any questions about this or anything else related to *BRN*.

Thank you for subscribing to *BRN* this past year, and I hope you will consider renewing again for 2008. All of us at *Bat Research News* wish you a happy, safe, and productive 2008!

Cheers,
Marg.

Observations of Mating Behavior in the Eastern Red Bat (*Lasiurus borealis*)

Luke E. Dodd and Joshua K. Adkins

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On 13 September 2007, we observed mating of the eastern red bat (*Lasiurus borealis*) while conducting a mist-netting survey at a closed-canopy stream in the Cumberland District of the Daniel Boone National Forest, Bath County, Kentucky. The sky was clear, with fair weather and a temperature at sunset of 19 °C. We captured one male northern bat (*Myotis septentrionalis*) and four *L. borealis*. All *L. borealis* were males; two individuals possessed descended testes and two did not. After collecting data on sex and reproductive condition, we released the bats ca. 7 m from the netting area.

A pair of bats was observed ca. 2 h after sunset (2030 h EDT), flying in a looping pattern (ca. 2 m in diameter), with one individual following the other. These bats were making vocalizations detectable by both the human ear and an ultrasonic detector (Anabat II, Titley Electronics, Australia). Less than a minute later, the bats landed on the stream bank and began copulating within 3 m of the authors. The bank consisted of gravel lightly littered with deciduous foliage, which may have provided a cryptic location for terrestrial activity. After the bats landed, we observed their behavior intermittently (ca. every 1 min) using the low-light setting of a headlamp.

Copulation consisted of a series of 2–3 min bursts of activity followed by 3–5 min of rest. During bursts of mating activity, the mounted individual, presumably a female, appeared motionless. The top bat, presumably a male, clasped the female at the torso, and made readily discernable thrusts. During a period of inactivity, one of us approached to 1 m of the mating bats. This allowed positive identification as an eastern red bat based on body size and coloration, which are unique to bats in this region (Barbour and Davis, 1969). When approached, the copulating bats remained motionless, but after photos were taken and the author retreated, mating activity recommenced. Despite the vocalizations heard while the bats were in flight, no audible or ultrasonic sounds were detected while the bats were on the ground. After ca. 15 min of copulation, activity ceased, but the mating pair remained joined and stationary for an additional 15 min. The two bats eventually took flight in separate directions.

In other regions, mating by *L. borealis* typically occurred in late summer and autumn (Cryan and Brown, 2007; Shump and Shump, 1982), and the timing of our observation in eastern Kentucky was similar. However, most previous descriptions of mating in *L. borealis* noted that coupling occurred in flight (Cryan and Brown, 2007), whereas we witnessed apparent pre-copulatory behavior in the air and independent landing on the ground. While capturing *L. borealis*, Saugey et al. (1989) observed multiple males entering mist nets within a few centimeters of a female and suggested that males were pursuing females for breeding; our observations support their interpretation. In a later paper, Saugey et al. (1998) noted a male *L. borealis* entering a mist net and initiating copulation with a female that was already caught in the net, indicating as in our study, that coupling may not always occur in flight. Thus, we suggest that observations of mating may not be the consequence of aerial accidents on the part of the copulating bats, as suggested by Glass (1966).

We thank M. J. Lacki and L. K. Rieske for helpful comments on earlier drafts of this manuscript.

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Using Ultrasound to Determine Pregnancy in Small Bats in the Field

Allen Kurta and Rodney Foster

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Wildlife managers are intensely interested in quantifying reproductive rates of wild animals, to establish the health of a population and also to determine whether managerial manipulations (providing nest sites, added food, etc.) are effective. For living bats, the usual method of determining pregnancy in the field is palpation of the abdomen. This method is woefully inadequate, prone to error, and essentially an art practiced by experienced personnel. Most bats weigh only 5–20 g; consequently, embryos and fetuses are extremely small. It often is impossible to determine whether a female is pregnant by palpation during the first trimester, and in mid-pregnancy, presence of a fetus may be obscured by food in the digestive tract. Even if a fetus is palpated, it is impossible to estimate its size and, therefore, its approximate age.

Use of ultrasound to determine pregnancy and to measure the size of an embryo/fetus is established practice in human and veterinary medicine. However, this technique never has been used with small mammals in the field, presumably because of the large size and electrical requirements of the equipment. Nevertheless, technological advances have resulted in field-portable instruments, and we wanted to know whether such equipment could be used with species such as the endangered Indiana bat (*Myotis sodalis*), a small (7–10 g) bat of the eastern United States for which there is essentially no data available on rates of pregnancy. As a surrogate, we evaluated use of the equipment with the similar-sized little brown bat (*Myotis lucifugus*).

The instrument that we assessed was the Palm 2000 Ultrasound Scanner, which is made in China and marketed in the U.S.A. by Medisales, Inc., Los Alamitos, California. We chose this equipment because of its low mass (600 g), small size (15 by 12 by 4 cm), and ability to operate on rechargeable batteries. Although the cost ($5,000 US) was high for most biologists, the price was low relative to other, less portable machines. The Palm 2000 comes with a standard probe that emits ultrasound of 3.5 MHz and an optional probe that operates at 5.0 MHz. We selected the 5.0-MHz instrument because, as in echolocation, a higher frequency means a smaller wavelength and a better ability to detect small objects.

Five pregnant bats were captured at a barn in Lenawee County, Michigan, at dawn; two were caught on 14 May and three were obtained on 27 May 2007. Each bat was palpated after capture and then examined ultrasonically. The three bats from late May also were transported to a veterinary clinic, where they were examined with a 7.5-MHz instrument (Sonovet 600, Medison America, Cypress, California). The focal depth of both scanners exceeded the thickness of the bat, so we followed common veterinary practice and used one or two 2.5-cm-thick gel pads, commonly termed "stand-off" pads (Aquaflex, Parker Laboratories, Fairfield, New Jersey), to increase the sonic thickness of the animal. A standard ultrasound transmission gel (Other-Sonic, Pharmaceutical Innovations, Newark, New Jersey) was used between the pads and the scanner. Afterwards, the bat was sacrificed by exposure to carbon dioxide, the embryo removed, and its size (crown-to-rump length) measured with a ruler.

We were able to palpate embryos in the range of 16–19 mm in three animals but not 12–13 mm for the other two. The Palm 2000 was able to detect the three larger embryos but not the smaller ones. We could not make reliable measurements of the size of the embryos using either ultrasound scanner because the weight of the stand-off pads, as well as our gentle restraint of the animal, appeared to distort the images.

Hence, our brief investigation suggests that the Palm 2000 is no better than palpation as a tool for diagnosing pregnancy in bats as small as little brown and Indiana bats, and this machine is not appropriate for measuring the size of a fetus in such species. Instruments having a shorter focal depth and operating at 20 MHz or greater likely would be better for determining pregnancy in very small bats without distortion, but such instruments are used primarily by dermatologists in clinical settings and are much more expensive (e.g., Episcan, see http://www.longportinc.com). Although the Palm 2000 is not practical for bats weighing 7–10 g, we suggest that its use be investigated in larger species, such as those that weigh more than 40 g. Presumably these more robust animals would require no stand-off pad or at least a much smaller one.

T. McCormick (Village Animal Clinic, Farmington, Michigan) provided helpful advice. C. Rockey and B. Schaetz assisted. This project was funded partly by a grant from the Graduate School, Eastern Michigan University.

Abstracts of Papers Presented at the Symposium

Fossils, Molecules and Morphology — Evolutionary History of Bats

Organized for the 2007 Society of Vertebrate Paleontology Annual Meeting

Austin, Texas
17–20 October 2007

The following abstracts are from papers presented at the symposium entitled "Fossils, Molecules and Morphology — Evolutionary History of Bats," which was organized for the 2007 Society of Vertebrate Paleontology Annual Meeting held in Austin, Texas. The symposium abstracts are reprinted here with permission of the Society of Vertebrate Paleontology. The co-conveners of the symposium were Gregg F. Gunnell (University of Michigan), Nancy B Simmons (American Museum of Natural History), and Thomas P. Eiting (University of Massachusetts). Margaret Griffiths thanks the Society of Vertebrate Paleontology and the co-conveners of the symposium for allowing the abstracts to be reprinted in *Bat Research News*. Any errors that may have been introduced during the preparation of the symposium abstracts for reprinting here are inadvertent, and Margaret Griffiths, the Editor, asks that you please accept her sincerest apologies.

Molecular Based Geological Timescale on Flight from Insectivory to Feeding on Blood, Vertebrates, Fruit, Nectar: Phyllostomid Bats

Robert Baker[1], Olaf Bininda-Emonds[2], Ron Van Den Bussche[3], Calvin Porter[4], and Steven Hoofer[1]; [1]Texas Tech University, Lubbock, TX 79409; [2]Technical University of Munich, 07743 Jena, Germany; [3]Oklahoma State University, Stillwater, OK 74078; [4]Xavier University of Louisiana, New Orleans, LA 70125

Only 2 of 19 bat families have evolved to feeding on plant material. We use a well-supported phylogenetic tree built from nuclear and mitochondrial genes to estimate both time and order of diversification to an array of feeding strategies. The primitive feeding strategy for the common ancestor of phyllostomid and mormoopid bats was strict insectivory, but the basal diet for all extant phyllostomid bats was primarily insectivory with some plant material, as is characteristic for the extant genera *Macrotus, Micronycteris,* and *Glyphonycteris*. We hypothesize that the dietetic adaptation to some plant material was critical to diversification to feeding on blood, nectar, vertebrates, or fruit. The initial diversification within phyllostomid bats is estimated to be in the early Oligocene (~30 mya). We hypothesize that morphological and dietary condition of primarily insectivory and plant material as in *Macrotus* and *Micronycteris* was typical of the last common ancestor of the respective lineages that gave rise to blood, carnivory, nectar, and fruit eaters. The lineage giving rise to blood feeding diverged from all other phyllostomids 28.1–25.3 mya and became an apparent obligate blood feeder by 22.0–21.4 mya. Two independent lineages of nectar feeders diverged from other phyllostomids 22.3–18.4 and 21.4–20.2 mya, respectively. The lineage that gave rise to frugivory diverged 19.7–17.6 mya. The latter time agrees well with the only other instance of the evolution of frugivory in bats (Old World Pteropodidae, estimated to have diverged 24 mya, suggesting that a global, transtropical floral shift facilitated bat frugivory in these two families). Successful sanguivory, nectivory, and frugivory require extensive evolutionary change in morphology and physiology to accommodate the necessary suite of adaptive phenotypes. That so many alternative feeding strategies could evolve from a

single common ancestor (26 mya), and in a comparatively short timeframe, must have required exceptional genetic mechanisms to facilitate change. We discuss how a phylogenetic tree can interface with genomics to understand change over time.

New Basal Noctilionoid Bats from the Oligocene of Florida, USA

Nicholas Czaplewski[1] and Gary Morgan[2]; [1]Oklahoma Museum of Natural History, Norman, OK 73072; [2]New Mexico Museum of Natural History, Albuquerque, NM 87104

A number of Oligocene and Miocene localities in Florida have produced abundant microvertebrate fossils including rare specimens of Chiroptera, a group with a sparse pre-Pleistocene record in North America. At two of the localities, I-75 and Brooksville 2, the bats include several specimens of a large and a small species, both belonging to an undescribed new genus, probably of a new family. The samples overlap in including an upper molar of each species; this tooth is identical in the large and small species except for size. Only the large species is present in the Brooksville 2 fauna, where a better sample is available including an upper molar and all of the lower teeth except the incisors. The Brooksville 2 local fauna represents the late early Arikareean LMA (25–28 Ma; late Oligocene). Each of the two species is represented by a single tooth in the I-75 local fauna, which we interpret as being late Whitneyan LMA (about 30 Ma; late early Oligocene) in age. Parsimony analysis of available dental-osteological data suggests that the new bats are sister to a mystacinid-noctilionid-mormoopid clade, which in turn is sister to Phyllostomidae. The two species of the new family co-occur in the same localities with a new genus and species of mormoopid; together the three are the earliest known representatives of the Noctilionoidea. The age of these specimens more than doubles the known time depth of the noctilionoid lineage, previously known back to 12–13 Ma (Laventan LMA) in South America. Both of the Florida localities reflect deposition in paleokarstic situations and suggest a probable cave-dwelling habit for the bats. Several other families of bats also occur in various other late Oligocene and early Miocene sites in Florida (Emballonuridae, Mormoopidae, and Natalidae). Biogeographically, the occurrence of the new noctilionoids and these other families in what is now peninsular Florida, where these groups no longer exist, bolsters other faunal data suggesting a subtropical to tropical aspect to the Florida paleoenvironment in the middle Cenozoic, and a Neotropical influence or possible tropical North American origin for the Noctilionoidea.

Flight and the Evolution of Feeding in Bats

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Roughly a quarter of all mammal species are bats and they occupy all but the coldest and most remote habitats on earth. Flight was certainly a key innovation behind their success, and adaptations for aerial locomotion are clear in the postcranial skeleton, where the form and composition of skeletal elements are uniquely modified to enhance aerodynamic function. Has flight had an equal impact on the structure of the skull and, if so, how might it have affected the evolution of feeding? Here I present data on the density and scaling of skull bones in bats, passerine birds, rodents, and “insectivorans” (i.e., erinaceomorphs, soricomorphs, and afrosoricids). Skull bone volume and mass scale with isometry in all groups, illustrating that skull bone density is constant across these disparate vertebrate taxa. Surprising patterns emerge when skull mass is regressed on brain mass. Both bats and birds exhibit low skull mass relative to brain mass but they accomplish this in very different ways. Skull mass scales with strong positive allometry in birds, rodents, and insectivorans; birds simply have much less bone. Bats, on the other hand, are unique in that skull mass and brain mass scale with only very slight positive allometry. Thus, although the skulls of bats are not as lightweight as those of birds, they clearly bear the mark of selection for weight minimization. With respect to feeding, the skulls of bats are more likely to be tuned to the mechanical demands of feeding and less likely to be "overbuilt" than the skulls of other mammals. Links between skull structure and the loads encountered during feeding are explored using finite element models of New World leaf-nosed bats (Phyllostomidae) that exhibit very different skull shapes and feeding behaviors.

Regional and Global Perspectives on the Quality of the Fossil Record of Bats

Thomas Eiting and Gregg Gunnell; University of Michigan, Ann Arbor, MI 48109-1079

The idea that bats have a poor fossil record is a pervasive one. Much recent work investigating the evolutionary history of bats has focused principally on molecular and morphological analyses of extant forms, with utilization of the fossil record only to provide calibration points in phylogenetic analyses. Although rarely attempted, studies of completeness and of the quality of the fossil record of bats have important consequences for our understanding of evolutionary rates, patterns, and relationships among chiropterans. We compiled a database of Cenozoic fossil bat genera at the finest known stratigraphic level (usually sub-epoch or stage) and coarse geographic provinces. We tabulated each genus as a separate record if its known age differed across its geographic range. This resulted in approximately 350 unique genus-locality occurrences and 240 distinct genera. Of the approximately 180 extant genera, 72 (40%) occur as fossils. At least 13 genera of modern bats have fossil representatives from a geographical province different from their modern distribution. There are at least 55 bat genera known only from fossils. In this analysis we applied phylogeny-independent methods to analyze completeness of the bat fossil record. We also used genus-level phylogenies, to which we applied consistency- and gap-based metrics, to analyze the quality of the bat fossil record. Initial results suggest that the quality of the bat fossil record may not be as poor as previously thought, at least for some groups and some geographic regions. Vespertilionidae has one of the best fossil records, in part because two of the best-sampled regions, Europe and North America, contain many of the genera with good records. At the subepoch-level (and without dissecting genera according to the method outlined above), the preservation probability of a bat genus may be as high as 67%, with a corresponding completeness of 82%. Although likely an upper limit, this value at least provides a first approximation of the genus-level completeness of the bat fossil record. It suggests that bat fossils—especially of extinct genera—may provide crucial insight into the phylogenetic relationships of this group.

Back to the Future—African Vespertilionoidea (Chiroptera) and the Antiquity of Myotinae

Gregg F. Gunnell[1], Thomas P. Eiting[1], Elwyn L. Simons[2], and Erik R. Seiffert[3]; [1]University of Michigan, Ann Arbor, MI 48109-1079; [2]Duke University Primate Center, Durham, NC 27705; [3]Oxford University, Oxford OX1 3PW, UK

Vespertilionidae is the most diverse extant bat family with 34+ genera and 260+ species. Controversies surround the interrelationships of vespertilionids but a traditional subdivision based on molar tooth morphology (nyctalodonty vs. myotodonty) is useful for grouping most major subclades. Nyctalodont (postcristid connects hypoconid and hypoconulid) forms include murinines, pipistrellinins, lasiurins, and some plecotins, while myotodont (postcristid connects hypoconid and entoconid, isolating hypoconulid) forms include myotines, antrozoins, kerivoulines, and the majority of vespertilionins and plecotins. Nyctalodonty has been viewed as primitive for vespertilionoids with taxa such as Late Eocene/Early Oligocene *Stehlinia* exhibiting that pattern. Myotodont vespertilionids previously have not been recorded prior to the Early Oligocene (MP 21) when *Myotis*-like forms began to appear in Europe. Recent fieldwork in Fayum, Egypt has led to discovery of a new myotodont vespertilionid from late Eocene sediments at Quarry L-41 (34 Ma). This bat resembles extant myotines but differs in having relatively larger and more robust c1 and p2-3, p3 double-rooted, and molars relatively shorter and broader; differs from *Stehlinia* in having p2 larger than p3, p3 much smaller than p4, p3-4 not homodont, p4 relatively more elongate, and myotodont molars; differs from Early Oligocene *Quinetia* in having an elongate and more robust p4, and myotodont molars with excavated talonid basins and lacking lingual cingulids. An extinct group of myotodont bats, the Philisidae, also is represented from Fayum, including three (possibly four) species ranging in age from 37 to 30 Ma. Philisids (Early Eocene to Early Miocene) traditionally have been viewed as a sister group (and possibly ancestral) to vespertilionids. However, philisids are more derived than the L-41 myotin in lacking p3. This suggests that a philisid-vespertilionid split must predate 37 Ma, that myotodonty may be primitive for both of these clades (or the combined clade if they are sister taxa), and that it may be prudent to look to Africa as a possible source area for the origination of myotodont vespertilionids.

Shoulder Joints and Inner Ears of *Tachypteron franzeni*, an Emballonurid Bat from the Middle Eocene of Messel

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Tachypteron franzeni is the only one of seven bat species known from Grube Messel (near Darmstadt, Germany) that can be assigned to an extant family. This extraordinarily well-preserved fossil shows trabecular microstructures of the elongated tuberculum majus of the humerus and also internal microscopic details of the cochlea, which compare well to emballonurid species (e.g., *Taphozous melanopogon*, *T. kachhensis*) and also to other extant bats with similar morphological specializations (e.g., *Molossus molossus*). These details are made visible by µCT and high resolution radiographs and—in addition to other morphological characters—strongly support the view of a rapid and constant flight style for *Tachypteron franzeni* in combination with an echolocation system adapted for hunting in the open air above the forest canopy. Thus, this type of ecological adaptation extends the known spectrum of foraging strategies in the Messel bat community to the extreme of high altitude flight foraging, which obviously also existed during Middle Eocene of Messel. A couple of different radiographic and tomographic methods (like µCT, µCT-laminography, µCT-tomosynthesis, and limited angle µCT) were applied and compared in this study to meet the demands of very small regions of interest and proved invaluable, even though the specimen is preserved on a very much larger fossil plate.

Australian and New Zealand Bats: The Origin, Evolution, and Extinction of Bat Lineages in Australasia

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Australian Paleogene and Neogene bats, and New Zealand's first pre-Pleistocene bats, enable study of community structure, resource partitioning, foraging behavior, faunal turnover, and patterns of extinction in Australasian bat communities throughout the Cenozoic. They also provide opportunities for testing molecular phylogenies and competing biogeographic hypotheses concerning the origins and evolution of the Australasian bat fauna. The Australian fossil record documents the pre-Pleistocene presence of all extant Australian bat families, with the notable exception of Pteropodidae and Rhinolophidae. Archaeonycteridids, a radiation of mystacinids, and bats yet to be assigned to family are also represented. Data from Australia's Riversleigh World Heritage Area are used to quantify change in diversity and abundance of bat lineages and communities during three greenhouse/icehouse cycles in the Cenozoic, providing a tool to help anticipate the response of bat communities to current and future climate change and to inform development of effective conservation strategies. New Zealand's (NZ) Early Miocene fossils include bats referable to three modern families as well as taxa that appear to have no close living relatives. Although yet limited, the NZ fauna has affinities with Eocene (55 Ma) and Oligo-Miocene (25–12 Ma) Australian faunas, as well as Eurasian and South American bat faunas. Like Australia's Neogene bat communities, NZ's Miocene bats appear to have been derived from more than one geographic source. The fossils enable testing of the "out of Asia" versus "out of South America" biogeographic hypotheses (based on analysis of both molecular and morphological data) for several extinct and extant Australasian bat lineages. Palaeoecological hypotheses about the evolution of terrestriality in NZ bats are also tested. Chiropteran fossils indicate that there have been substantial changes to the Australasian bat fauna since the Miocene, with trans-Tasman dispersal and a cooling climate contributing to this turnover. They add further weight to calculations of extinction risk and phylogenetic diversity loss for several lineages, including *Mystacina*.

Developmental Dynamics of Chiropteran Molars: On Variation and Constraints

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The enamel architecture of adult molars (SEM), its embryonic development, pre- and perieruptional changes in teeth shape and dynamics of enamel maturation in selected model taxa (mostly vespertilionid bats) revealed that the tribosphenic molars of bats are composed of several, more or less independent, structural modules: the crests of (a) paracone, (b) metacone, and (c) protocone, (d) parastyle and (e) palatal cingulum, in the upper molars, (f) the trigonid crest, (g) hypoconid crest (cristid oblique partim, postcristid), (h) entoconid and (i) labial cingulum, in the lower molars. The variation in basic design of these components and their positional relations are largerly constrainted within the insectivorous bats, whereas there is a large variation in the structures interconnecting the basic modules and/or extending the essential tribosphenic design (e.g., mesostyle, protofossa, para- and metalophs, hypocone and talon, hypoconid fossids, mesial cristid obliqua, distal postcristid, entoconid crest). The design of these structures is often clade specific. As the enamel must be completely hardened prior to tooth eruption, all of these characters have to be attained during tooth development via the specific heterochronies. These heterochronies and the way the particular structural modules are integrated into the tooth phenotype are thus the essential characteristics of particular clades. Nevertheless, some phylogenetic morphoclines may appear in common: e.g., disappearance of some intermodular elements due to a prolonged developmental autonomy of individual modules (comp. e.g. myotodonty in lower molars) or a scaling of variation and role of some structures with prey and body sizes. With larger prey the original crown design (spacious protofossa, well developed para- and metalophs and mesostyle) is often effected by increase in height of the dentition, and decrease in the role of protocone-talonid occlusion compared to that at the intermolar-trigonid complex where the respective structures go underdeveloped compared to the prolonged lateral elements of the plagiocrista (common in megadermatids, hipposiderids, or among vespertilionids such as murines or Paleogene Phylisinae).

Evolutionary Trends in the Chiropteran Brain: A Comparative Analysis of Bat Sensory Ecology

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Recent debates in bat systematics surrounding the precise placement of the Pteropodidae with respect to other bat families have given rise to new questions regarding patterns in the evolution of echolocation, and to a lesser extent, other bat sensory capabilities. The implications of the recently proposed groups Pteropodiformes and Vespertilioniformes are that the ability to echolocate was either lost in the Pteropodidae or was convergently evolved in the Rhinolophoidea and the Vespertilioniformes. To address this question I analyzed volumes of the inferior or superior colliculi, the hippocampus, the olfactory bulbs, and the auditory nuclei of 139 bat species using the PDAP set of programs. I conducted these analyses using both the molecular framework (Vespertilioniformes and Pteropodiformes) and the traditional framework (Megachiroptera and Microchiroptera). In both cases results very strongly suggest that echolocation is an ancient trait of the Chiroptera and thus forms another line of evidence that the Pteropodidae might have lost this ability. The results for other capabilities (olfaction, vision, spatial memory) suggest these characteristics are more highly labile and might be subject to selection, rather than phylogenetic constraint.

***Necromantis*: New Data and Relationships**

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Necromantis adichaster Weithofer is a large bat, described on the basis of fragmentary material of uncertain age from the Paleogene Quercy Phosphorites fillings, SW France (19th Century collections). Revised by Revilliod, *Necromantis* has been attributed to the paleotropical family Megadermatidae as its oldest member. Additional material of *Necromantis* from past Quercy collections has become available, and modern fieldwork in the Quercy has provided further specimens from three well-dated localities. The presence of *Necromantis* in Western Europe is documented from at least the Middle to Late Eocene (~44–36 Ma). Dental, cranial, and postcranial morphology indicates that *Necromantis* was a large, robust bat adapted to predation on hard prey including small vertebrates and possibly carrion (as suggested by Weithofer's name for the taxon). The spherical condyle of the elbow joint is unspecialized, retaining the ability to rotate the forearm around the humeral axis and enabling maneuverable flight, ground-based predation, and take off with a heavy load. Striking dental features, such as the markedly median ectoflexus, lingually displaced mesostyle, and large and median hypoconulid, as also seen in early Eocene bats such as *Ageina* and *Honrovits* and retained in *Palaeophyllophora*, further suggest that *Necromantis* was a relict form specialized in carnivory and bone crushing. The new data indicate that some similarities between *Necromantis* and recent paleotropical bats such as megadermatids are convergent. Phylogenetic analysis of craniodental and postcranial data for 50+ extinct and extant bats also indicates that many features shared by *Necromantis* and megadermatids may be plesiomorphic. Collectively, the current evidence does not support the referral of *Necromantis* to Megadermatidae. In dated molecular phylogenies *Necromantis* is commonly used as a calibration point for minimum age of the split between megadermatids and other rhinolophoids. Our research suggests that this calibration is invalid, and its removal may lead to revisions in molecular estimates for divergences within bats.

Evolutionary History of the Neotropical Chiropteran Fauna

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Our work on bats from the Oligocene and Miocene of Florida and the Miocene of Colombia has produced fossils representing eight of the nine New World (NW) chiropteran families, only three of which (Phyllostomidae, Vespertilionidae, Molossidae) were known previously from pre-Pleistocene faunas in North America (NA) or South America (SA). Paleokarst deposits in Florida have produced the oldest fossils of three Neotropical groups: Mormoopidae (new genus) and a basal noctilionoid (new genus) from the Oligocene (28–30 Ma) I-75 and Brooksville 2 (Br2) faunas, and Natalidae (†*Primonatalus*) from the early Miocene (18 Ma) Thomas Farm (TF) fauna. Eocene bats from western NA now under study may be crucial to resolving the origin of the Noctilionoidea (Noctilionidae, Mormoopidae, Phyllostomidae, Thyropteridae, Furipteridae) and the NW Vespertilionoidea (Vespertilionidae, Molossidae, Natalidae). Two new genera from the Florida Oligocene and Miocene are the earliest NW records of the pantropical Emballonuridae. Pre-Pleistocene records of the pantropical Molossidae from NA include: the earliest member of the family from the Eocene of Saskatchewan (†*Wallia*), an undescribed genus from Br2, *Tadarida* or *Mormopterus* from TF, *Eumops* from the Pliocene of Arizona, and *Tadarida* from the Pliocene of Florida. A Pliocene vampire bat (*Desmodus*) from Florida is the oldest NA phyllostomid. The oldest bats from SA are teeth (indet. family) from the Eocene of Argentina and Peru and the molossid *Mormopterus* from the Oligocene of Brazil. The mid-Miocene (12–13 Ma) La Venta (LV) fauna in Colombia documents the earliest SA records of four Neotropical families: Emballonuridae (*Diclidurus*), Noctilionidae (*Noctilio*), Phyllostomidae (†*Notonycteris*, †*Palynephyllum*, genus near *Tonatia* or *Lophostoma*), and Thyropteridae (*Thyroptera*). LV also has three genera of molossids (*Eumops, Mormopterus,* †*Potamops*) and the only pre-Pleistocene vespertilionid from SA. Beginning in the early Pliocene, the Great American Biotic Interchange led to an extensive mixture of NW chiropteran faunas, including Pliocene records of *Eumops* and *Desmodus* in NA (both of SA origin) and the migration of mormoopids and natalids to SA (both of NA origin).

Cephalometry and Evolutionary Constraint with Respect to the Mode of Echolocation in Bats

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The fundamental construct of the head is strongly influenced by the growth of the brain and pharynx early in development. Differential growth of the two determines the shape of the chondrocranium and overlying bones. Spatial competition among other components within the confines of the fetal head imposes spatial and mechanical constraints on the adult skull. Cephalometric relationships among skull components in both embryos and adults distinguish taxa that echolocate nasally (Rhinolophidae, Phyllostomidae) from those that echolocate orally. During ontogeny, skulls of nasal-emitters are distorted by the rotation of the basicranium ventrally about the cervical axis, depression of the rostrum below the basicranium, and rotation of the lateral semicircular canals to a near-horizontal orientation. These actions align the nasal cavity with the axis of the body in flight. Heads of oral-emitting taxa are instead constructed around an axis aligned with the oral cavity. Brain size is poorly correlated with skull cephalometry; rather brain size is associated with the occupation of a specific aerial niche, rather than skull shape. In sum, the skull mechanics of echolocating bats are constrained by the demands of vocalization and have been canalized along two distinct developmental paths: oral and nasal-emitting bauplane. An extreme example of the nasal-emitting bauplan is found in rhinolophid bats where the nasal cavity has been extensively modified as an acoustical horn (loud vocalization). Subsequent distortion of the rhinolophid maxillae results in unique rostral fontanels, loss of lacrimal bones and infraorbital foramen, and reduction of the anterior palate such that the premaxillae are kinetic. In contrast, rostra of phyllostomid nasal-emitters exhibit large eyes and extensive turbinate development (quiet vocalization). Given the spatial restrictions of the midface, the anatomical correlates of olfaction and echolocation have apparently worked at cross-purposes during the evolution of the nasal-emitting rostrum. Perhaps we need to step back and reevaluate development as a way of understanding the evolution of an organism—perhaps we can no longer see the forest for all the gene-trees.

The Primitive Condition of Lower Molars among Bats

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Among various tooth characters found in insectivorous bats, two distinctive patterns in lower molars (particularly m1 and m2) are recognized. The most common pattern is nyctalodonty, in which the posterior crest (postcristid) extends from the labial hypoconid cusp to the disto-lingual hypoconulid cusp and then to the entoconid. The other, less common pattern is myotodonty, in which the postcristid (which is taller and sharper than in nyctalodont forms) directly connects the hypoconid to the entoconid, isolating the reduced hypoconulid on the posterior face of the entoconid. Transitional conditions between these patterns are rare, but occur in a number of extinct and extant species. These two major dental morphotypes correspond to two different evolutionary steps. Myotodonty is more specialized, the taller, sharper postcristid enhancing its cutting function against the anterior face of the metacone of the upper molar. Some bats reported from Early Eocene strata on some continents (e.g., Europe, North America), mainly archaeonycterids *s.l.*, display typical nyctalodonty. However, other early Paleogene bats from various areas (e.g., *Ageina, Honrovits, Necromantis, Palaeophyllophora, Australonycteris* as well as unnamed or undescribed bat material) are characterized by large hypoconulids in a median or sub-median position. This feature, being found in diverse, ancient lineages, most likely represents the primitive condition among bats, characterizing also the (as yet unknown) earliest bats. Here we name this dental morphotype necromantodonty. Necromantodonty, and to a large extent the general tooth morphology in these latter bat taxa, is shared by various insect-feeding arboreal fossil eutherians (e.g., early leptictids, nyctitherians, adapisoriculids, euprimates), including those that are probably closely related to bats.

A New Primitive Bat from the Early Eocene of Wyoming: Fossils, Phylogenetics, and the Evolution of Echolocation and Flight

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Bats (Chiroptera) represent one of the largest and most diverse radiations of mammals, accounting for one-fifth of extant species. Although recent studies unambiguously support bat monophyly and a consensus is rapidly emerging regarding phylogenetic relationships among extant lineages, early evolution of the group remains poorly understood. An undescribed bat from the Early Eocene Green River Formation of Wyoming (ca 52.5 Ma) provides a new view of the earliest stages of bat evolution. Known from two nearly complete skeletons, this animal exhibits several features that are more primitive than seen in any previously known bat. Phylogenetic analyses, including those using a molecular scaffold, unambiguously indicate that the new bat represents the most basal known branch of Chiroptera, with *Icaronycteris* (also from the Green River Formation) occupying the next most basal branch. The evolutionary pathways that led to flapping flight and echolocation in bats have been in dispute, and Eocene fossils, although remarkably well preserved, have been of limited use in documenting transitions involved in this dramatic change in lifestyle. Comparisons of the new taxon to other bats and non-volant mammals demonstrate that critical morphological and functional changes evolved in an incremental fashion. Forelimb anatomy indicates that the new bat was capable of powered flight like other Eocene bats, but basicranial morphology suggests that it lacked their echolocation abilities, supporting a "flight first" hypothesis for chiropteran evolution. Shape of the wings suggests that an undulating gliding-fluttering flight style may be primitive for bats. Presence of a long calcar in the new bat indicates that a broad tail membrane evolved early in Chiroptera contra previous hypothesis, probably functioning as an additional airfoil rather than a prey-capture device. Limb proportions and the retention of claws on all digits suggest that the new bat may have been an agile climber that employed quadrupedal locomotion and underbranch hanging behavior in its locomotory repertoire.

Molecular Phylogenetics Investigates the Bat Fossil Record

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The evolutionary history and biogeographic origin of the order Chiroptera (bats) is rife with conflicting hypotheses due to competing phylogenetic trees and a poor fossil record. However, recent large molecular data sets (exons, introns, and mitochondrial data) have provided conclusive, congruent support for the paraphyly of Microchiroptera and for the phylogenetic position of most families. Currently, the phylogenetic positions of Miniopteridae, Craseonycteridae, and Myzopodidae are still in dispute due to inadequate data and conflicting results. To resolve the phylogenetic positions for these families, a combined nuclear supermatrix (~15 kb, nuclear introns and exons) was generated, collected, and analyzed using traditional phylogenetic techniques. This new phylogeny was used to: 1) elucidate the biogeographic origin of bats and the resulting four superfamilial microbat clades; 2) investigate the extent of missing fossil data in light of molecular divergence dates. Both the 'Out-of-Africa' and Laurasiatherian hypotheses for the origin of bats were assessed using evolutionary biogeographic reconstruction methods. These theories were further investigated in light of recent fossil evidence.

Ancient DNA Sheds Light on the History of Mouse-eared Bats (*Myotis*) in Europe

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Nietoperzowa Cave in southern Poland has more than 33 fossils of mouse-eared bats of known age (ca. 800 years BP) that if DNA was preserved in a useable fashion could provide unique opportunities for studying historic population genetics of these animals. We successfully isolated DNA and sequenced the entire cytochrome *b* gene (1,140 bp) from seven fossilized specimens of mouse-eared bats. Fossil haplotypes were either identical with contemporary haplotypes, or differed from the latter by one or two substitutions. To provide a better understanding of levels of genetic variation at this locality, we included fossil specimens in a phylogenetic study of mouse-eared bats from Europe and Asia Minor. Our results document that two sibling species were present at Nietoperzowa Cave for at least the past 800 years (about 400 generations) and that they diverged in allopatry relatively recently (560,000 years BP), corresponding with the Donau II stage of glaciation. We also found that these volant mammals followed the general "bear-paradigm" characteristic of post-glacial dispersal of several terrestrial mammals in Europe. Finally, inclusion of nuclear RAG2 sequence data from contemporary individuals and their consideration in context of the cytochrome *b* tree revealed possible interspecific hybridization events of ancient and recent origins.

Abstracts of Papers Presented at the
XIV International Bat Research Conference
and 37th North American Symposium on Bat Research
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The following abstracts are listed in alphabetical order by first author. Contact information for authors who attended the conference can be found in the list of meeting participants, which follows the abstracts. Many thanks to Joaquin Arroyo-Cabrales, Cristina Espinosa, Jose Juan Flores-Martinez, Gabriela Lopez, and Rodrigo A. Medellin for compiling the abstracts and list of participants. Any errors that may have been introduced in the preparation of the abstracts for publication in *Bat Research News* are inadvertent, and I ask that you please accept my sincerest apologies. Margaret A. Griffiths, Editor

Conservation International — Brazil Programme
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The Cerrado region of Brazil, comprising 21 percent of the country, is the most extensive woodland-savanna in South America. It is located between the Amazon and Atlantic rainforest. Today the Cerrado is the major agribusiness (soybean, corn, and irrigated rice) frontier of the country. Nearly one-quarter of all grain produced in Brazil comes from the Cerrado, and there are more than 49 million hectares of planted pasture for cattle grazing. *Lonchophylla dekeyseri*, a small nectarivorous bat, also lives in this same habitat. Until recently this bat was known from only three localities. However, the Brazilian Government, through its Environment Ministry, launched a program called "Action Plan for endangered species," and a two-year study identified *L. dekeyseri* within this region. We will present the results of this study, including population gene flow and habitat fragmentation, radiotelemetry, and population persistence simulations, demonstrating that basic research is needed to delineate an action plan and try to ensure that bat species survive in this biome.

Bat Frugivory in a Remnant of Southeastern Brazilian Atlantic Forest
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Knowledge of bat diets may be important for the conservation of small Atlantic Forest fragments because bats play an important role in seed dispersal and natural recuperation of tropical forests. The "Reserva Particular do Patrimônio Natural Feliciano Miguel Abdala" (RPPN-FMA) is an 886-hectare Atlantic Forest fragment consisting of a mosaic of distinct successional phases resulting from logging and natural causes, in the state of Minas Gerais, Brazil. We collected 216 fecal samples containing blood, arthropods, pollen-nectar, vegetation (leaflets and fruit peel), fruit pulp (fibers and juice), and seeds, from 18 bat species at the RPPN-FMA. Piperaceae, Solanaceae, Cecropiaceae, and Guttiferae were the most important food resources for frugivorous bats at RPPN-FMA. Piper infrutescences supported *Artibeus obscurus*, *Artibeus fimbriatus*, *Carollia perspicillata*, and *Sturnira lilium* throughout the year, functioning as key species as already observed for other tropical rainforest sites. Bat frugivorous communities seem to be adapted to food resource partitioning, and higher niche overlap is expected between taxonomically close or morphologically similar species. In the present study, we found considerable niche overlap for six related frugivorous species. Annual activity patterns of these species may explain their coexistence: most bat activity and abundance occur in the rainy season when availability of fruit resources is higher at the study site. Such bat-mediated seed dispersal is very important in fragmented habitats and/or very disturbed forests, promoting plant re-colonization in these areas. Considering that the RPPN-MFA is a conservation unit designed to protect remnant primate populations in the region, knowledge of interactions among frugivores and plants is crucial to its management.

Rabies as Focus for Scientific Research

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Bats are known to be the origin of most of the members of the *Lyssavirus* genus, including the classic rabies virus. In Latin America, vampire bats (VB) (*Desmodus rotundus*) have caused hundred of cases of human rabies and thousands of cases of cattle rabies. In the United States and Canada, *Lasionycteris noctivagans* is known to be responsible for the few autochthonous human rabies cases and, in Europe, *Eptesicus serotinus* accounts for 95% of cases of human exposure to the European Lyssavirus 1. These human and animal rabies fatalities have made bats the object of scientific research. Our research team studied the prevalence of rabies in several species of non-hematophagous wild bats, in the central Pacific coast of Mexico. We also studied the experimental rabies infection in VB—maintained and breeding in captivity—and their immunization against this disease. Prevalence studies showed positive results as high as 37% affecting 15 different species. Experimental rabies infection showed that vampire bats are 150,000 times less susceptible to rabies virus than foxes and, that under certain conditions, bats could act as asymptomatic carriers of this disease. Anti-rabies immunization experiments showed that it is possible to protect bats against rabies by using aerosol vaccines. Reproductive control in VB was also studied as another alternative to control rabies outbreaks. Phytooestrogens adversely affect the gonads of VB and thus affect their fertility. Most bats (except for vampire bats, which are considered a plague) are beneficial and their conservation is beyond all doubt. We think that vaccinating bats would not only protect them, but it would also prevent the dissemination of the rabies virus to other susceptible mammals, as has been demonstrated with dog and fox vaccinations.

Bat Vocalisations and Applications of Echolocation Surveys for Inventorying Bats (Symposium Summary)

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Bats are well known for their emission of ultrasound signals. Recording and analysis of echolocation calls has become a powerful tool for a wide variety of approaches. This symposium brings together a presentation of new results on the practical use of echolocation calls for acoustic identification, inventorying, and monitoring of bats in the field. Furthermore, it demonstrates that some bat species have developed a much larger vocal repertoire, which is mainly used in a social context in addition to the “classical” echolocation behavior that mostly serves for spatial orientation and foraging. Species identification of bats based on acoustic characteristics is increasingly used in applied, conservation-oriented research to assess distribution patterns of species and to characterize the effects of anthropogenic disturbance on structure and dynamics of species assemblages with the main focus on the little known group of aerial insectivorous bats. Use of acoustic signals for species identification, inventories, and monitoring as well as the linkage of social vocalizations with a defined behavioral context require standardized methodology and a well-set conceptual background.

Use of Acoustic Methods for Bat Inventory and Habitat Use Studies in Bolivia

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During the last decades, acoustic monitoring of bats has been increasing rapidly thanks to the development of newer technology and better bat detectors and microphones. The Bolivian Bat Conservation Program started to use this technology in 2000, and since then it has become a key method not only for the identification of bat species but also as a starting point for comprehensive studies on habitat use by bats. The Bolivian bat fauna currently consists of 122 species. Some of them are known for the country only because of the use of acoustic detectors. As an example, the bat fauna of the city of Cochabamba was surveyed almost exclusively by means of acoustic methods, revealing, among others, seemingly rare bat species such as *Promops nasutus* (Molossidae) as regular inhabitants. This study, combined with a preliminary survey of a Neotropical savanna in the Beni area of Bolivia using various bat detector models, doubled the number of aerial insectivorous species known for the area in a short period of time. In the savanna, we investigated habitat use by aerial insectivorous bats in a forest island-savanna matrix. Combined with mist netting, our first data reveal that some species are mostly restricted to the interior of forest islands (e.g., Phyllostomidae), whereas other species make extensive use of the external borders of forest islands (i.e., *Molossops temminckii*) or open space (*Eumops perotis*). Overall, the use of bat detectors complements the “classical” bat surveys conducted with mist nets and is a very valuable tool for ecological studies of little known aerial insectivorous bats in Bolivia. Therefore, standardization of the survey and thorough documentation of echolocation signals used for species identification are of the essence.

The Bolivian Bat Conservation Program, Research, and Education: Lessons Learned

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Bats play a major role in maintaining healthy ecological processes, and thus in maintaining the biodiversity of the ecosystems that they inhabit. Yet bat populations continue to be jeopardized by many human activities. In Bolivia, activities such as habitat destruction, misconceptions about bats, and misleading campaigns aimed at controlling vampire bat populations and the rabies transmitted by them, all lead to the destruction of bats and their natural roosts. To deal with these problems, the Bolivian Bat Conservation Program (PCMB) was created in 1998. The PCMB uses both education and research in its efforts to change people’s attitudes toward bats and to increase their knowledge regarding the role of bats in Bolivia’s ecosystems. Since its creation, the educational component of PCMB has reached more than 150,000 people by means of school activities, museum exhibits, vampire bat workshops, and other activities. Since initiating the research component of PCMB, the number of known

Bolivian bat species has increased from 106 species in 1998 to 122 species in 2006. This includes rediscovering *Lonchorhina aurita* in Bolivia after 74 years. Additionally, the conservation status of Bolivian bats was recently re-categorized by the Program, and 17 species are now listed in different "threatened" categories. Action plans for those species are being prepared, and research and public outreach will continue for many years to come.

Bat Conservation in Latin America: Lessons Learned and Future Perspectives (Symposium Summary)

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Latin America holds almost half of the bats known currently in the world and the threats they have to face are several. Habitat destruction, misleading vampire bat controls, misconception among the population, folklore, and others have big impact on several bat species, several of which are considered threatened. To minimize those impacts on bats, several efforts have been conducted in the region that include research and education directed to bat conservation. Among the first programs in Latin America are the Mexican Bat Conservation Program (PCMM) and the Bolivian Bat Conservation Program (PCMB). These two programs started a grassroots activity helping to organize sister organizations that work independently towards bat conservation in their own countries. The programs have succeeded in changing peoples attitudes, organized workshops to permit proper vampire bat controls without harming beneficial bats, and conducted research that rediscovered species thought to be extinct or not found in decades. Some of these activities resulted in management plans of bat species and habitats, and also in the inclusion of bats in Red Lists within their countries. The symposium seeks to gather all of the active programs in Latin America, share their experiences, and discuss a regional Alliance (ALCOM) with common goals to guarantee bat conservation in Latin America and the processes in which they are involved.

Temperature Variation as a Potential Metabolic Benefit in Bifid Style Tent, in Costa Rica

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Bats use a great number of preexisting roosting sites, such as caves or hollow trees, but in the tropics a few species modify leaves as roosts, termed tents. The benefit of constructing tents is expected to be higher than the cost of building a tent; however, the benefit obtained by bats has not yet been evaluated. A possible benefit of tents is their protection against low temperatures, which may cause an excessive and critical waste of energy for bats especially in the birthing season. We searched for bifid style tents at La Tirimbina, in Heredia, Costa Rica to measure temperatures with I-button (each 30') for a week. We compared the temperature of tents with the respective control (leaves without modification, of similar size and height in the same plant) using a paired t-test. We found 31 tents, the majority of which were on *Asterogyne martiana*. We found no significant differences between the mean temperatures of the tent and the control leaves. The temperature during the first hours of the day was higher in tents than in controls, whereas after 12 hours the temperature in the control was higher. During the night the temperatures remained almost the same for both tents and controls. We are not certain that bats save energy from roosting in tents, but we infer that perhaps the major energy benefit comes from roosting in pairs or groups.

The Phylogenetic Position of the Philippine Endemic "*Pteropus*" *leucopterus*

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Pteropus is the most speciose genus in the Pteropodidae family, including 65 species in 18 species groups. Many species are endemic to islands in the Indian and Pacific Oceans and are highly endangered. Since 1912, when Knud Andersen published his Catalogue, the monophyly of *Pteropus* was rarely questioned, although previous authors had placed some forms in separate genera. Here we show that *Pteropus* as currently understood is not monophyletic. DNA samples were obtained for 18 *Pteropus* species, representing 12 species groups, and representative megachiropterans as outgroups. Three nuclear genes (RAG1, RAG2, vWF) were sequenced for these samples and analyzed using maximum parsimony, with clade support assessed by bootstrapping and Bremer support index. A combined analysis of the gene sequences (> 3 kb) shows high support to a clade containing *Acerodon* as sister to all *Pteropus* species, to the exclusion of the Philippine endemic *P. leucopterus*, making *Pteropus* paraphyletic. In view of these results, two potential taxonomic decisions were evaluated: inclusion of *Acerodon* in *Pteropus*, or segregation of *P. leucopterus* from *Pteropus*. We opted for the latter solution, for which a genus name was available: *Desmalopex* Miller, 1907. Therefore we consider *Desmalopex* as valid, and resurrect the combination *Desmalopex leucopterus*. We anticipate further modifications of the composition of *Pteropus*.

Spatial Foraging Pattern in a Population of Long-fingered Bat (*Myotis capaccinii*)

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The long-fingered bat, *Myotis capaccinii* (Bonaparte, 1837) is an endangered species in Europe, and hunts for arthropods or small fishes from the water surface. Foraging habitats include rivers, pools, lakes, and channels, preferring smooth water surfaces. We studied the spatial foraging pattern of 45 individuals by radiotelemetry in the lower basin of Xúquer River (Eastern Iberian Peninsula, Western Europe). We surveyed the changes in the distance from the roost to the foraging sites, length of foraging area, and aggregation/dispersion of foraging areas for three seasons (pre-breeding, lactation, and post-lactation), comparing the results for different age, reproductive stage, and sex classes. Overall, 90% of the foraging activity of the population concentrated within a 10-km radius around the roost, although some bats moved further, up to 22.7 km from the roost. Pre-breeding bats gathered at two collective foraging areas, which coincide with the richest patches of arthropod abundance. During lactation individual foraging areas reached the maximum dispersion and maximum average distance from the roost. The average size of the foraging areas reached the highest value during post-lactation, when young bats seemed to explore the available aquatic habitats in the area. In each season the spatial variables did not change significantly among classes.

The Population Ecology of Daubenton's Bat (*Myotis daubentonii*)
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Daubenton's bat is being used as a model species to investigate the behavioral and ecological basis of population structure, by combining field-based studies with molecular genetics. In particular, we are investigating the changes in population structure and behavior that result from a change in habitat quality with altitude. We have shown that this species is sexually segregated along an altitudinal gradient, with females being found only at intermediate and low elevations, where the habitat can supply the needs of pregnant and lactating females. A minority of dominant males share roosts with and monopolize the breeding females at intermediate elevations, and father disproportionately more offspring than the larger group living upstream, perhaps by mating before the nursery colonies disperse. The males living at higher elevations have lower body condition indices despite foraging for longer within larger home ranges. They also show significantly greater fluctuating asymmetry in their wings, suggesting reduced fitness. These apparently less fit individuals may mate only during autumn swarming. At the lowest elevations nursery roosts are almost exclusively female, raising the question: "what mating strategy is operating if the males do not appear to roost with and monopolize the females? We are addressing this question by (a) extending our genetic analysis of population structure and paternity to the lowest elevations (b) using PIT tags, and automated PIT tag loggers at roost entrances, to look in more detail at roosting associations in summer colonies and swarming sites.

Impacts of Wind Energy Development on Bats: Hypotheses, Patternism, and Potential Solutions
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At a time of growing concern over the rising costs and long-term environmental impacts from the use of fossil fuels and nuclear energy, wind energy has become an increasingly important sector of the electrical power industry, largely because it has been promoted as being emission free and is supported by government subsidies and tax credits. However, large numbers of bats are being killed at utility-scale wind energy facilities, especially along forested ridge tops in the eastern United States (US). These fatalities raise important concerns about cumulative impacts of proposed wind energy development on bat populations. This paper summarizes evidence of bat fatalities at wind energy facilities in the US, makes projections of cumulative fatalities of bats in the Mid-Atlantic Highlands, identifies research needs, and proposes hypotheses needed to address these concerns to better inform researchers, developers, decision makers, and other stakeholders to help find ways to avoid or minimize adverse affects of wind energy development.

Bats on Chinese Stamps: Over Three Centuries
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In 1894 the China Custom Posts issued Empress Dowager commemoratives to honor the 60th birthday of the reigning monarch. Two stamps have five stylized bats in a ring surrounding the tree of life. Called "wu-fu" bats symbolize the five great happinesses: health, wealth, long life, good luck, and tranquility. When the Customs Post was changed to the National Post in 1897, they were overprinted, giving birth to several new issues. This symbol of five bats is also found on recent stamps from the Republic of China as well as the People's Republic of China. Stylized bats were also printed on a set of six different Hong Kong scenes in 1941, and on two stamps commemorating the return to peace in 1946. More recently various objects decorated with bats—kites, bowl, etc.—have been depicted on stamps of the Republic of China, People's Republic of China, and Macao. They are sometimes very hard to identify on so small drawings. The only bat species on one stamp of the Chinese area is *Pteropus dasymallus formosus*, depicted on a 1993 issue of the Republic of China. Interestingly the margins of the sheet depict enlargements of its face and feet. Modern Chinese philately is characterized by printing a lot of postal stationeries. After the postcard issued in 1993 to honor the 11th International Congress of Speleology, several items depict bats, but this is another story.

Counting Bats in Tropical Cave Roosts Using a Simultaneous Infrared Video and Ultrasound Detection System: An Attempt in a Mexican Deciduous Forest Habitat

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Periodic counts of individuals present in cave roosts are necessary to assess population trends and conservation status of bats. However, counting bats in roosts at tropical locations, where the animals are continuously active and large numbers of individuals of different species can be found together, might become a daunting enterprise. In this work we assessed the feasibility of counting multi-species concentrations in deciduous tropical forest habitat by using simultaneous infrared video and time division plus time expansion ultrasound detection to record the bats emerging from five underground roosts. Recordings were obtained every six weeks along one year, and emerging bats were counted on the video image running at a slow pace, and identified by the wing shape and echolocation call structure shown in a parallel computer screen. The roosts were used by important populations of the emballonurid *Balantiopteryx plicata*; the mormoopids *Mormoops megalophylla*, *Pteronotus parnellii*, and *P. davyi*; the phyllostomids *Desmodus rotundus*, *Macrotus waterhousii*, *Leptonycteris curasoae*, *Glossophaga soricina*, *Artibeus jamaicensis*, and *A. hirsutus*; the natalid *Natalus stramineus*; and the vespertilionid *Myotis velifer*. *Balantiopteryx plicata*, *M. megalophylla*, *P. parnellii*, *P. davyi*, and *M. velifer* broadcasted powerful diagnostic echolocation sounds, while all the other species produced very faint non-diagnostic calls and were difficult to tell apart easily in the video image. Even in the case of the species with diagnostic calls, it was very difficult or time-consuming to tell the species of every bat during massive simultaneous emergences. Fortunately, there was little overlap in the time of emergence of most species with diagnostic calls, and most times they could be reasonably counted. In those species the audiovisual recording allowed us to obtain population estimates impossible to get by direct counts inside the roosts. The method, while not perfect, allows getting important information for a good number of species.

Migratory Bats and Wind Turbines in Alberta: Temporal and Spatial Variation in Bat Activity and Fatality

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Wind energy is one of the fastest growing energy sectors in the world. Southern Alberta currently has 16 wind farms with ~400 total turbines producing ~400 MW, and numerous other projects in various stages of development. Between 1 August and 15 September 2005, at Summerview Wind Farm located in flat cropland east of the Rocky Mountains, 532 dead bats were found, an average of 13 bats per turbine. Total estimated fatality was ~16/turbine accounting for scavenger losses (insects). The summer/fall of 2006 showed a similar pattern, with 619 carcasses found between 15 July and 30 September. The fatality rate at this particular wind farm is distinctive in the area; most other sites have fatality rates < 1 bat/turbine/year. The timing and composition of fatality is comparable with other North American wind farms; the majority of fatalities are migratory tree bats (silver-haired and hoary bats). Using acoustic monitoring and carcass searches, I am examining variation in fatality rates and bat activity levels. To determine regional activity levels, I deployed bat detectors at 30 m and ground level at eight sites across southern Alberta (~200 km between the most westerly wind farm and the most easterly). Activity levels varied among sites and between heights. I conducted daily carcass searches at 10 of the 39 turbines at Summerview, and weekly searches at the remaining 29 turbines. Fatality varied from night to night and turbine to turbine. Fatality variations may be correlated with weather variables, and this correlation may suggest mitigation strategies. A mitigation experiment is being performed in the summer/fall of 2007. The operational parameters of half of the Summerview turbines (20/39) are being altered to assess the effectiveness of this mitigation strategy. Preliminary results of this experiment will be presented.

Flying Squirrels Don’t Glide Steady: Implications for Bat Evolution

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Many hypotheses regarding the origins of bat flight envision a gliding ancestor for bats. In these scenarios, gliding is viewed as a steady-state phenomenon (maintaining a constant velocity and glide angle), from which gradual increases in wing length allow for progressively longer glides and selection favors the longest glides. In this study, we test key assumptions of this model, by testing the hypotheses that 1) mammalian gliders employ steady-state aerodynamics during their glides, and 2) mammalian gliders seek to maximize distance traveled during glides. Two high-speed cameras (125 fps) were used to track the glides of wild Northern flying squirrels (*Glaucomys sabrinus*). From these videos, the 3D trajectories, velocities, accelerations, and aerodynamic forces were calculated for the middle portion of the glide, to test the expectation of steady-state conditions. We find that the squirrels never utilize steady-state gliding, and instead accelerate to higher velocities that produce more aerodynamic force than needed to balance body weight. This causes the squirrels to reduce their sinking velocity continuously and achieve a progressively shallower glide until they are moving upwards at the end of the glide. This continual reduction in sinking velocity allows the squirrels to maintain a relatively constant horizontal velocity and reach their destination in less time and with less loss of altitude than a steady-state glide. These results suggest that optimum glide performance criteria may include

maximizing speed and/or maneuverability, in addition to, or instead of maximizing distance. We propose that speed and maneuverability could confer selective advantages for evading predators and for pursuing aerial insect prey. Models centered around maximizing glide distance have been unable to explain how flapping would originate in a gliding protobat. Our findings that gliders are not limited to gliding in simple steady-state fashions suggest flapping motions could improve glide performance by enhancing maneuverability, stability, and speed.

Bat Talks—Infectious and Mutualistic Enthusiasm!

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Whether you are talking about bats with elementary school children, senior citizens, or a mixed-age audience, the same general features contribute to an effective, educational, and exciting experience. First, know your audience and do your homework: what ages are involved, how many people are expected (some things only work with small groups), what are their (or their teacher's) specific expectations, what background do they have? Second, show your enthusiasm for the subject—it is infectious. If possible, include some of your own research and experiences to add a personal touch to the presentation. Third, avoid jargon but don't talk down to your audience. Children know more than you think and are not afraid to ask questions…hard questions. Mixed-age audiences can be a challenge, but adults understand that you have to speak at a level the younger members can grasp. Fourth, ask the audience questions; children, especially, like to show what they know. Be prepared for stories…a few of which may actually be true. Fifth, have some hands-on activity, especially for younger children. Whenever possible, bring a live bat and be prepared for it to be the star! Let the audience see it up close, hear (watch) it echolocate with a bat detector, and see it drinking or eating. Take the group on a bat-walk in the evening after the presentation. Listen for bats at sunset using a bat detector, and bring a mist net or harp trap to show the audience how researchers catch bats. Last, be prepared to have fun and be energized by your audience! Their enthusiasm is also infectious.

Runs in the Family—Comparing Vocal Communication and Its Functional Significance in Two Sheath-tailed Bats

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Acoustic signals play a major role in the social interactions of bats. However, the cryptic and nocturnal habits of most species have hindered extensive behavioral field research. Nevertheless, the discovery of suitable roosts for observation and the development of increasingly sophisticated technology in high-frequency recorders have made it possible to document both the behavioral and acoustic components of social interactions in some species. Within the family Emballonuridae, important advances have been made in the comprehension of the communication and social organization of *Saccopteryx bilineata*. Detailed research on this species has revealed an exceptionally extensive vocalization repertoire linked to complex social behavioral patterns, which are presumably mainly driven by its polygynous mating system. The related proboscis bat, *Rhynchonycteris naso*, is sympatric with *S. bilineata* in most of its range.

Despite its relatively high abundance and conspicuous roosting behavior, the social structure and behavior of these bats is mostly unknown except for some anecdotal observations. Previous studies have found a conspicuous lack of visual displays and so far none has recorded any vocalizations during social interactions. In 2006, we observed a colony of *R. naso* for seven months in Costa Rica. We used ultrasound and video recording devices to understand the characteristics of their communication signals and their importance within the colony dynamics. We found them to have a rich vocal repertoire of mostly high-frequency calls of diverse structure, which varies in composition during different social interactions. By assessing the similarities of our findings on *R. naso* with the well-known *S. bilineata*, we provide for the first time a quantitative comparison of the structural characteristics of acoustic communication during social interactions of these two related species.

Promoting Bat Conservation through Environmental Education: Program for the Conservation of Bats of Costa Rica (PCMCR)

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Bats play an important role in tropical forest ecology for their part in insect population control, seed dispersal, and pollination. Therefore, the protection of bat populations could be part of an integral solution to challenges in natural habitat recovery and conservation. In Costa Rica, human-induced habitat loss and direct persecution of wild populations have been identified as the greatest threats to the survival of bats. Therefore, the Program for the Conservation of Bats of Costa Rica (PCMCR) was created in 2001 with the mission of reducing such conservation threats through two major axes of action: Environmental Education and Research. From 2002 to 2005, in collaboration with governmental and private organizations, more than 500 students from 15 elementary schools in rural areas received informational workshops on bat biology and their importance for ecosystem conservation. Starting in the 4th grade, children were taught about different aspects of bat ecology through story and activity booklets featuring one fictional character for each dietary habit of tropical bats (e.g., frugivores, nectarivores). The series of workshops was completed when the students graduated from the 6th grade having studied about three types of bats common in their area. Using a standard evaluation questionnaire before each workshop, we measured the progress of the children's knowledge acquisition about bat biology and their awareness towards the threats to bat conservation. Having completed one cycle of workshops with the first students of PCMCR, we herein present the results of this educational experience in Costa Rica in terms of successful outcomes, difficulties encountered, and future perspectives.

Microclima and Bugs (Cimicidae): A Possible Cause of Roost Switching by Vespertilionid Bats

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The objectives of the present study are to extend the knowledge about influence of the microclimate and interaction of bats with roost ectoparasites, bugs of group *Cimex pipistrelli*. Previous results have shown frequent movements between different shelters in pipistrelles. The changes in occupation of three bat boxes used by *Pipistrellus pygmaeus* and the dynamics in numbers of the bugs ibidem were studied. Models indicated that internal relative humidity better accounted for the fluctuation in bat numbers during pregnancy and lactation than did changes in the internal temperature. Three variables (internal humidity, external temperature, and number of bats) accounted for almost 90% of the variability in internal roost temperature, while the number of bats accounted for only 29% of the variability. A negative correlation was found between the internal temperature and the number of bats roosting in a bat box during pregnancy and lactation. The internal temperature of a roost with bats was biased by thermoregulation strategies induced by the bats during particular reproductive periods. The decrease in bug numbers began only several days after the bats had left the boxes. After a month of the bats' absence, the abundance of adult bugs decreased by half of their number. Only the eggs survived the period when the roosts were unoccupied in summer. In mid-July, after the arrival of lactating females, an increase in the number of bugs was observed; however, no new eggs were found. Although eggs were able to survive the hot period, they were negatively influenced by high humidity in autumn and only adult bugs survived the winter period. The bats, by shifting the roosts within the vegetation season, both avoid high roost temperatures and prevent the massive reproduction of these parasites. [The study was supported by the grant of MEYS CR No. MSM0021622416 and the CSF No. 206/07/P098, 206/06/0954.]

Differences in the Flying Activity of Four *Myotis* Species at the Entrance of Hibernacula

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The study of bat flying activity at the entrance of natural caves can provide knowledge about the structure of bat assemblages, which use them as shelters. Our goal was to assess the sex and age structure of four *Myotis* populations visiting natural hibernacula during the pre-hibernation period (15 July–14 November)—i.e., after the summer colonies disappear and their activity changes. Data were collected between 1991–2006 and all of the period under study was divided into 10-day intervals. In total, 2,559 bats were captured during 527.2 netting-hours by means of mist nets (entering bats) and special cage-traps (emerging bats) placed at the entrance of Kateřinská cave. The four most abundant species—*Myotis bechsteinii*, *M. daubentonii*, *M. nattereri*, and *M. emarginatus*—were selected for the analysis. The flying activity of all bat species under study changed during the pre-hibernation period but the pattern is species specific. The peak of flying activity was registered in late August with the exception of *M. nattereri*, which was the most active during the second half of October. The activity was minimal at the beginning (July 15–26) and the end (November 4–14) of the period under study. The level of activity was influenced mainly by adult males as females visited the cave entrance only occasionally and their activity reached nearly the zero-level in September and November. Moreover, the Body Mass Index of males was negatively correlated with their flying activity (statistically significant for *M. bechsteinii*, *M. daubentonii*, *M. nattereri*) and we can assume that the entrance of Kateřinská cave is used also as the mating locality for bat species under study. [This research was supported by grants GA CR 524/05/H536 and MSMT 0021622416.]

The Molecular Evolution of Visual Perception within Bats

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Bats are successful nocturnal animals that exist in diverse ecological niches throughout the globe. Their global success is largely attributed to their unique ability to fly and use sophisticated laryngeal echolocation. However, it has been argued that bats have developed this acoustic sense at the expense of their other senses, such as vision. Not all bats are blind, nor can they all echolocate. The fruit-eating megabats have large eyes specialized for nocturnal vision and cannot use echolocation. Microbats that echolocate rely more on sound than on vision to navigate at night. Recently published molecular data indicate that megabats were once able to echolocate, but have now lost this acoustic ability by selecting for vision. To investigate the genomic consequence of environmental niche specialization and a possible sensory 'trade-off' in bats, we amplified and sequenced genes involved in vision from echolocating microbats, non-echolocating megabats, and other distant mammals. Conserved, divergent, or absent regions within these genes were identified and correlated with the mode of sensory perception among bats. We examined if selection had occurred within these genes over time due to environmental niche specialization.

Variation in Bat Diversity within Four Different Environments in a Disturbed Area of Tabasco, Mexico

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Variation in bat diversity must be monitored to know the changes that can present themselves in disturbed environments over time. The variation of bat species was analyzed during three years in four different vegetation types in a floodable area of Tabasco, Mexico. Sampling was done using fog nets in tintal, mangrove swamps, secondary vegetation, and croplands, encompassing dry, rainy, and tropical storm seasons (nortes). The species richness was estimated, plus the diversity by season and vegetation type, and the similarity per vegetation between seasons. Twenty-six bat species were registered; two are at risk (*Rhynchonycteris naso* and *Trachops cirrhosus*). Secondary vegetation registered the greatest richness (20), next the tintal (15), and lastly mangrove swamps (9). The secondary vegetation presented the largest variation, ranging from 0–11 in nortes and dry seasons, respectively (in 2005). The mangrove swamps varied from 0 during the rainy season to 5 in the nortes and dry seasons (2004). In the tintal the number of species varied from 4–12 in the rainy seasons (2004 and 2005, respectively). The largest diversity was obtained during the rainy season (2.95) and the least in the nortes season (2004). Secondary vegetation presented the least diversity (0) during the nortes season (2005), remaining constant, with a maximum during the dry season of 2004 (2.747). In tintal the largest similarity (1) was obtained during the dry seasons (2005 and 2006), dry and rainy seasons (2005), and with nortes season (2006). The mangrove swamps presented similarities between nortes and dry seasons (2005 and 2006, respectively). Secondary vegetation had the strongest similarity (1) between dry seasons (2005 and 2006). Croplands had the least similarity (0.88) for the nortes season (2004 and 2005). The tintal and the secondary vegetation are important in maintaining bat diversity in disturbed areas over time.

Advancing Conservation Biology Literacy through Bat Conservation Education Initiatives: Resources from the Network of Conservation Educators and Practitioners
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Limited access to educational and training resources represents one of the greatest obstacles to building capacity in biodiversity conservation. To address this issue, the Center for Biodiversity and Conservation of the American Museum of Natural History and its partners developed the Network of Conservation Educators and Practitioners (NCEP, http://ncep.amnh.org). The NCEP project has two main objectives: to increase university professors, educators, and conservation practitioners' access to high-quality instructional materials relating to biodiversity conservation, and to foster an active approach to teaching and learning that attempts to model the realities of conservation practice. NCEP develops and freely disseminates a series of multi-component teaching modules in several languages (English, French, Laotian, Spanish), and runs local professional development workshops for educators. Existing NCEP modules, such as “Why is Biodiversity Important?” and “Ecosystem Loss and Fragmentation,” are designed to facilitate student participation and engender the application of critical thinking to conservation issues. Because each module combines key background information, a visual presentation with instructor notes, and practical exercises to address relevant topics in biodiversity conservation, these modules can be used to complement existing bat education curricula and promote awareness of the importance of bat conservation and management within the scope of biological conservation. Currently, more than 60 complete or partial modules are available and have been used to fulfill a variety of education and teaching needs. Evaluations of efforts indicate that module usage continues to increase, the modules ovide current information on relevant conservation topics, are easily modified to meet teaching needs, include multi-disciplinary and global perspectives, and increase active learning. Here, we highlight the applicability of NCEP teaching resources and professional development activities to conservation education projects in a variety of fields, including *in situ* efforts dedicated to protecting bats through education and conservation.

Conservation of Bats in Europe
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This presentation considers 48 nation states in Europe including the Caucasus states in the east, Malta and Cyprus, and the European islands of the North Atlantic. The bat fauna comprises 48 currently recognized species of which seven are endemic. Bats are protected in most countries by national legislation and through a range of international directives and treaties. Through the IUCN Global Mammals Assessment, the conservation status of all species was recently assessed for the region and separately for the 25 members of the European Union (EU). At the intergovernmental level, the Agreement on Conservation of Populations of European Bats (EUROBATS) develops practices and policies to implement obligations from its articles as well as those of the EU Habitats and Species Directive and the Bern Convention. Information for the benefit of bat conservation is presented through meetings of the European Bat Research

Organization and national and international publications. A wide range of NGOs participates in the conservation of bats in Europe and may soon collaborate through a new organization, BatLife Europe (similar to BirdLife). Bats living in densely populated and highly developed European areas are benefiting from modern scientific research, education programs, landscape planning and guidance, and designation of conservation areas. The long-recognized seasonal migrations of bats in Europe and concerns with respect to climate change highlight the need for international collaboration and co-ordination of bat conservation in an area that incorporates a large number of geographically small nation states.

Ancient DNA Sheds Light on the History of Bats in Europe

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Under certain conditions small amounts of DNA can survive for long periods of time and may be used as substrates in the Polymerase Chain Reaction for the study of phylogeny and population genetics of extinct animals and plants. About 20 years ago, DNA sequences were described from an extinct subspecies of the plains zebra and an ancient Egyptian human; what made these sequences exceptional was that they were derived from 140- and 2,400-year-old specimens. More recently, ancient DNA (aDNA) has been used to study phylogenetic relationships of protists, fungi, algae, plants, and higher eukaryotes such as extinct horses, cave bears, wooly mammoths, flightless moa birds, and Neanderthals. DNA sequencing of one of the mitochondrial genes of mouse-eared bats (*Myotis myotis* and *M. oxygnathus*) occurring in Europe allowed the comparison of aDNA sequences (dating back to ca. 820 years before present) with those of modern bats to assess their evolutionary relationships. Initial results reveal surprisingly complex population histories, and indicate that modern studies may give misleading impressions about even the recent evolutionary past. This is also in sharp contrast to research based only on morphology of fossils, which usually provides information about a particular petrified animal or plant. We also found that these volant mammals followed the general "bear-paradigm" characteristic of post-glacial dispersal of several terrestrial mammals in Europe. Finally, inclusion of nuclear RAG2 sequence data from contemporary individuals and their consideration in context of the cytochrome *b* tree revealed reciprocal interspecific hybridization events of historic and recent origins.

Stereotypy and Individuality in the Male Song of *Tadarida brasiliensis*

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Although male song has been studied extensively in birds, comparatively little research has been conducted on mammals. Some bat species produce vocalizations that are associated with mate attraction and complex song has been examined in at least one species. Vocalizations should be stereotyped to facilitate species recognition yet may vary across males for individual recognition. During the mating season, *Tadarida brasiliensis* males produce song while performing displays towards receptive females or while defending territories from other males. Here we present an acoustical and syntactical analysis of *T. brasiliensis* song. We found that male vocalizations were highly stereotyped in a variety of ways. First, all songs were composed of up to three phrases: “chirps,” “trills,” and “buzzes.” Second, all bats used the same types of syllables in phrases. Third, structural rules were found for the order of syllables within phrases and the order of phrases within songs across bats. We also examined individuality and repeatability of syllables. We found that syllables were highly stereotyped within individuals for periods of up to three years. One syllable, the “B” syllable in chirp phrases, was highly distinctive between bats. Within the general order rules, different males used different numbers of syllables in their phrases and different numbers of phrases in their songs. Although song in *T. brasiliensis* is highly stereotyped, syllable acoustics and syllable emission patterns may be used to identify individuals.

Selection of Day-roosts by *Myotis keenii* at Multiple Spatial Scales on Prince of Wales Island, Southeast Alaska

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Keen’s Myotis (*Myotis keenii*) is thought to be rare, with one of the most limited distributions of any bat species in North America. Throughout much of its range, forests are being altered by timber management at a rapid rate. Understanding the gender-specific roosting ecology of bats at all relevant spatial scales is necessary to evaluate the impact of habitat alteration and effectively prioritize conservation efforts. From May to September 2006 we examined trees used as day-roosts by Keen’s Myotis on Prince of Wales Island in Southeast Alaska. We used an information-theoretic approach to determine habitat characteristics associated with day-roosts at the tree, plot, minimum roosting area, and landscape scales, and Akaike’s Information Criterion (AIC) to evaluate strength of evidence for each model. We tracked 13 females to 62 roosts in trees and 6 males to 24 roosts in trees. Females primarily roosted in cracks and cavities of cedar (*Thuja plicata or Chamaecyparis nootkatensis*) that were live with defects or dead in early stages of decay. Males primarily roosted in cracks or under loose bark of cedar and hemlock (*Tsuga heterophylla*) snags in early or intermediate stages of decay. Results of analyses at the tree scale suggest females are selecting roosts with optimal thermal benefits and males are selecting for roosts that are highly visible and relatively free of clutter. At the plot scale use by females and males was related to proportion of basal area belonging to roost-like trees. Analyses at the minimum roosting area and landscape scales were still in progress at the time abstracts were submitted.

Foraging Ecology of Frugivorous and Nectarivorous Bats at Cenotes in the Yucatan, Mexico

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Tropical deforestation is one of the most important environmental threats of our time. In the Yucatan, Mexico, tropical forest has been modified by natural and anthropogenic disturbances to such an extent that 70% of the land surface currently consists of secondary vegetation and barely 5% is primary forest. Within the modified landscape, such as pasturelands, cenotes (water-filled sinkholes formed by the dissolution of limestone), and their surrounding vegetation are important for maintaining bat diversity. Evergreen species are common on these sites, so we investigated the role of these vegetational components as a food source for frugivorous and nectarivorous bats. We surveyed bats and obtained fecal samples for 48 nights at two cenotes in pastureland. Pollen was collected from the fur of *Artibeus jamaicensis.* The phenology of the plants surrounding the cenotes was monitored every month. We caught 762 bats of 13 species. Ninety-three percent of captures were frugivores (six species) and nectarivores (one species). *A. jamaicensis* was the most abundant species (67%) whereas *Centurio senex* was the least abundant (0.2%). Bats consumed fruits of nine plant families, the most important of which were from the Moraceae and the Solanaceae. Pollen belonging to 14 species (5 of which were unidentified) in 8 families was recorded on the fur of *A. jamaicensis*, with Bombacaceae species showing the highest values. *Ficus* trees showed asynchronous flowering and fruiting, which resulted in fruit being available for bats for almost the entire year. During the dry season when fruits were scarce, *A. jamaicensis* consumed pollen and nectar from two Bombacaceae species. Our results indicate that in the agricultural landscape, the vegetation around cenotes must be conserved as it provides food and shelter for bats, facilitates the movement of bats across the deforested landscape, and promotes the pollination and seed dispersal of many Neotropical plants.

Mitochondrial Phylogeography of the Leisler's Bat (*Nyctalus leisleri*) in Ireland and across Europe: New Perspectives

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The Leisler's bat (*Nyctalus leisleri*) is a species of particular interest in Ireland. Across most of its range, which extents over the UK and most of Europe, the species is rare and considered vulnerable in many parts, with the exception of Ireland, where it is relatively common. Indeed, Ireland is considered to be the European stronghold for the species and is thus internationally important from a conservation viewpoint. Despite its obvious importance, however, very little is actually known about the Leisler's bat population structure, ecology, and dynamics. In this study, we examined a highly polymorphic portion of the mitochondrial DNA control region (D-loop), to assess the phylogeographic relationship of *N. leisleri* in Ireland with those across the rest of Europe, including the closely related species *N. azoreum* endemic to the Azores Islands. Results bring new perspectives to the phylogeography of the Leisler's bat in Europe, identifying two distinct lineages, which probably diverged in separate refugia during the last glacial maxima. One of the lineages is restricted to Ireland and the Azores (i.e., composed of the Irish Leisler's and *N. azoreum* specimens only). The second lineage has widespread distribution in the rest of Europe. Results indicate that Ireland represents a zone of secondary contact with the presence of haplotypes from both lineages. The absence of Irish Leisler's bat haplotypes in Europe suggests limited migration in relation to the European counterparts, which are known to undertake journeys of over 1,000 km between winter and summer roosts. These results have important implications for the conservation of this species in Ireland, and given its unique genetic makeup and restricted gene flow, protection of these populations should be a conservation priority.

Modeling Energy Expenditure During Hibernation: Are Bats as Energetically Limited as We Think?

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It is generally assumed that hibernation is a response to an energy bottleneck during winter. Furthermore, it is thought that cavernicolous hibernating bats are energetically constrained, although there are limited experimental data to support this claim. Evidence supporting this idea comes from mathematical models, but all previous models have considered only physiological characteristics while ignoring ecological and behavioral characteristics that affect energy expenditure. In addition, all models have been based on one hypothetical individual and thereby miss the importance of intraspecific variation in body condition and hibernation strategies. Therefore, we constructed a model that considers the energetic costs of hibernation, variation in cave microclimate, variation in microclimate selection, use of clustering, and the possible energetic benefits of active areas. Unlike previous models, we also consider variation in body condition and its effect on microclimate selection. This allows us to draw conclusions about the degree of energy limitation in an entire population, as opposed to in one hypothetical individual. We parameterized our model with previously published data as well as data we collected on microclimate selection and clustering. We provide evidence that hibernating bats may not be as energetically limited as previously suggested. In addition, our model can be adjusted to accommodate any hibernating bat species for which adequate data are available and it can be used to compare among species and to predict appropriate microclimates to maximize survival in cavernicolous species.

Thermoregulation in a Tree-roosting Population of Evening Bats (*Nycticeius humeralis*) during the Reproductive Season

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In temperate areas, one strategy that small mammals, such as bats, use to save energy is torpor, or the controlled lowering of body temperature. Torpor use varies based on ambient temperature, food availability, reproductive condition, and other factors. However, most studies of torpor in bats are on laboratory-acclimated animals, and only in the past decade have advances in technology allowed body temperature to be measured in the field. Although most species of bats in North America roost in tree hollows or under bark, no study has examined thermoregulatory patterns and use of torpor by these bats during the reproductive season in the wild. In 2004, a maternity colony of evening bats was discovered roosting in tree cavities and crevices, in southern Michigan, U.S.A., which represents the northernmost location for evening bats in North America. We are using temperature-sensitive radio-transmitters to determine torpor use by members of this colony and answer questions about thermoregulation in the wild by a southern species on the northern edge of its range.

Reproductive Status and Genetics Influence Fission-Fusion Behavior by Tree-roosting Big Brown Bats

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We used PIT tags and radiotelemetry to document roosting associations between approximately 40 tree-roosting big brown bats (*Eptesicus fuscus*) in Cypress Hills, Saskatchewan, Canada in 2003–2004. We assessed association frequency using a ratio index compared to expected values generated from null models using a modified Monte Carlo permutation procedure. Although bats switched roosts and potentially roost-mates about every two days, associations between pairs of bats were nonrandom, consistent with fission-fusion. Association patterns for adult dyads were significantly different in each of three reproductive periods (pregnancy, lactation, and post-lactation). The level of associations was significantly different between reproductive periods. Associations during pregnancy were stronger than in lactation or post-lactation and were dramatically weakest in post-lactation. Reproductive status of individual bats also affected level of association as mean dyadic associations of reproductive bats were significantly higher than between non-reproductive or mixed status pairs. These results provide evidence that within a fission-fusion system, constraints associated with reproduction affect social cohesion of roosting groups. We then determined whether related and/or matrilineal females preferentially roosted together and assessed the level of gene flow between roosting areas using data from nine microsatellite loci and a mitochondrial DNA control region segment. We compared relatedness to roosting associations assessed using a pair-wise sharing index for radio-tracked bats (2000–2002) and roost-tree trapping events (2002–2005). Roosting associations were not based on relatedness or matrilineal relationships. Female-mediated gene flow was restricted between roosting areas (F_{st} = 0.145) but male-mediated gene flow was not (F_{st} = 0.015). Despite female philopatry and preferred roost-mates, roosting associations are not based on genetic relationships suggesting kin selection is not important. We suggest the fission-fusion system is maintained by individual benefits gained through associations with preferred roost-mates (e.g., information transfer, allogrooming) and membership in the group (e.g., knowledge of roosting and foraging sites, thermoregulation).

How Loud Can You Whisper? Intensity Estimates of Echolocation Calls from Two Phyllostomid Bats and the Significance for Acoustic Surveys

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Although the family of New World leaf-nosed bats (Phyllostomidae) exhibits a very high ecological variation with more than 160 species exploiting food resources as diverse as fruit, pollen, nectar, leaves, insects, small vertebrates, and blood, there seems to be strong similarity in call design within this group. The typical phyllostomid call consists of short, multiharmonic, steeply frequency-modulated downward sweeps presumably reflecting the similar sensory challenge posed by highly cluttered foraging areas, where stationary food is mostly gleaned off surfaces. In addition, phyllostomids have been considered “whispering bats”, emitting echolocation calls of very low intensity (< 70 dB SPL) thus making them less eligible for

acoustic monitoring programs than their louder aerial insectivorous counterparts. We investigated echolocation call intensity emitted by two species of phyllostomid bats, *Macrophyllum macrophyllum* and *Artibeus jamaicensis*, on Barro Colorado Island in Panamá. Our results show that these bats emit much more intense calls than previously assumed, with source levels exceeding 90 dB SPL. This challenges the original classification of phyllostomids as whispering bats and in conjunction with other recent intensity estimates from other bat species suggests a re-evaluation of the intensity scale used to separate bats into low and high intensity emitters. In light of our findings these two species of leaf-nosed bats should indeed be loud enough to qualify as potential candidates for acoustic surveys. However, other factors such as the high individual and intraspecific flexibility and interspecific similarity in call design and the problem of dealing with the high directionality of their calls still pose challenges for future applications of acoustic monitoring within this group.

Bats, Bites, and Rabies Exposures in the State of Alagoas, Northeastern Brazil

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Bats are one the most diverse group of mammals in the world and they can live and share many types of environments with several animals, including human beings. The relationship between bats and humans can be mutualistic or can cause damage for one or both of them. Rabies is the main health problem to humans and bats that might cause death for both. Rabid individuals of more than 30 bat species have already found in Brazil, mainly in the south and southeastern regions. Little is known about bats and rabies in the northeastern region. Between 2003 and 2006, 81 people of the State of Alagoas, northeastern Brazil, were taken to the Tropical Diseases Hospital of Maceio due to bite exposures from unidentified bats. All of them received anti-rabies treatment and no positive case was found. From this total, 46 people lived in Maceio when the bite exposition happened and 35 lived in other cities of Alagoas. In 2006, two horses were bitten by the common vampire bat *Desmodus rotundus* in Maceio and one of them died from rabies. At rural areas of Maceio, three cases of rabies in equines were found and at least ten animals (pigs, lambs, and horses) were bled by vampire bats. Our data show that the rabies virus was found in urban and rural populations of bats and several cases of bat bite exposures in humans have happened in the Maceio region, including attacks by vampire bats. Prevention measures, such as rabies vaccination of local people (post-exposure immunization) and vigilance of exposures to bat bites, as well as studies and management of bats are necessary to prevent an outbreak of human rabies in the State of Alagoas.

Foraging Habitat and the Large Home Range of Allen's Big-eared Bat (*Idionycteris phyllotis*) in the Arizona Desert as Determined by Radiotelemetry

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In making bat management decisions, both foraging and roosting requirements must be considered. Allen's big-eared bat (*Idionycteris phyllotis*) is one of the rarest North American bat species. Three mines in the Black Mountains in Mojave County, Arizona are the only currently occupied known roosts for the desert subspecies (*I. p. hualapaiensis*). When bat gates were installed in three of four occupied roosts in 2001, the bats abandoned two of the gated mines, and moved to another ungated mine. In August 2004, 0.4 g Holohil transmitters were attached to 12 post-lactating *Idionycteris* captured at dusk, exiting from the ungated mine. The bats were tracked for the next 12 nights to determine foraging habitat and home range. Each evening for 3–4 hours, the authors were able to locate all 12 bats from the air in a Cessna 150 aircraft. Ground crews were directed to positions from which they could accurately triangulate the bats' positions. The bats traveled approximately 80 km roundtrip nightly between the roost in creosote bush scrub at 1000 m and the foraging areas in mesquite grassland and pinyon/juniper woodland (1500–2000 m). All but one of the tagged bats returned to their home roost nightly, while the lone bat would return every other night, suggesting an alternate roost to the northeast near the foraging area. The majority of the bats commuted a great distance each night from the Union Pass roost, despite the fact that many abandoned mines are located in the Cerbat Mountain foraging area. By the end of the study, all 12 of the bats were recaptured and weighed at the mine where they were banded. Ten transmitters were recovered in the roost; and two were retrieved about 39 km from the roost—one in pinyon/juniper below a granite cliff and another in scrub oak on the east side of the Cerbat Mountains. [This research was supported by an Arizona Game and Fish Department SWG grant. Research assistance was provided by FWS, BLM, and AGFD biologists and many volunteers.]

Detailed Population Genetic Structure of Two Migratory Cryptic Species (*Pipistrellus pipistrellus* and *P. pygmaeus*) in Continental Europe

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Ecological and behavioral variations are often the most visible features of morphologically very similar species. Two recently discovered European cryptic species, *Pipistrellus pipistrellus* and *P. pygmaeus*, differ in some aspects (e.g., calls, foraging, roosts, activity). To test if the migration and hibernation behavior differs between species, we screened historical (preserved museum samples) and recent (wing membrane tissues) material from underground mass hibernacula and sites of mass autumn invasions of pipistrelle bats (116 individuals, 10 localities). Using a PCR-based species identification method, we found no records of *P. pygmaeus* in this material. By examining the degree of population subdivision, a greater understanding of seasonal movements may be attained. Long migratory species may be expected to show low levels of genetic structuring. To compare genetic structure of both species, 15 polymorphic microsatellite markers were used. In 2006–2007 we collected wing membrane tissues from individuals of maternity colonies of *P. pipistrellus* (n > 250 ind.) and *P. pygmaeus* (n > 200 ind.). Colonies were in 20 to 700 km distance from each other, across the Czech Republic, Slovakia, and Ukraine. In spite of possible different mating behavior in *P. pygmaeus* (unconfirmed mass roosting in autumn and winter), genetic structuring of both species was very low and there were no signs of isolation by distance. This indicates high level of gene flow among populations even when separated by large geographic distances. The results suggest that mating during autumn migration or during hibernation is an important means of gene flow among populations. Future analysis of mtDNA structure can bring additional information about the relative importance of male- and female-mediated gene flow. [This research was supported by the Czech Science

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What Color of Light Should You Use?
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Researchers studying bat diet frequently use light traps to monitor the relative abundance of insects in the habitat in which the bats are foraging. Ultraviolet light is often the light chosen because Lepidoptera are attracted to this wavelength. Using only UV lights however, may not provide a true indication of insect presence because not all insects are attracted to this wavelength. We experimented with lights emitting four different wavelengths (blue, green, white, and UV) in a north Pacific coastal rainforest environment on Haida Gwaii (Queen Charlotte Islands), British Columbia to determine which color, if any, attracted the greatest number and diversity of insects. An effort was made to minimize the influence of location by placing five light traps (including one without a light) up in a line across a forest clearing, and then rotating the traps through the sequence each subsequent night. Although green and blue lights appeared to attract more insects, we found no statistically significant differences in mean total numbers of insects that each light captured, or in the number of orders/families represented in each sample. Combining samples of all four light traps however, did result in greater nightly diversity than from individual light traps. In spite of our effort to minimize the influence of location on trap success, it still remained an important factor. We recommend that if light traps are to be used to monitor insect abundance, a number of traps, each with different light colors be used, and that the location of each be carefully chosen.

Resource Distribution and Social Structure in Harem-forming Old World Fruit Bats: Variations on a Polygynous Theme
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The prediction that the spatial dispersion of resources important to females should dictate female dispersion and male mating tactics is fundamental to the theory of mammalian mating systems, but rarely tested in bats. In this study we investigated the relationship between the estimated spatial distribution of available roosts, female group size, male roost fidelity, and the strength of social associations in two species of harem-forming Old World fruit bats in the genus *Cynopterus*. We evaluated the daily movements of individuals and groups among roosts using radiotelemetry and roost censuses at two sites in Peninsular Malaysia. We found a high correspondence between the distribution of roost-sites, female group size, and male behavior, supporting the prediction that clumped resources would promote female aggregation and high roost fidelity in males. However, there were significant interspecific differences in the strength of male-female associations, which suggested that where roosts are abundant and similar in quality, regardless of their spatial distribution, the potential for males to monopolize mates depends on whether females move among roosts with, or independently of, males. We propose that interspecific differences in female behavior may be related to the costs of moving between clumped vs. randomly dispersed males. More generally, we suggest that a pluralistic

classification of social structure based on space use patterns of both sexes, rather than male mating tactics, could provide significant insight into the social mating systems of tropical bats.

Behavioral Ecology and Conservation of Australia's Only Trawling Bat, the Large-footed Myotis: A Review

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Amongst the myriad of microbat foraging modes, fishing and trawling behaviors have arisen multiple times in different phylogenetic clades. Whilst true piscivory is rare, several *Myotis* species show morphological adaptations to aquatic foraging. The inclusion of fish into the diet of these species has the potential to influence life-history characteristics such as the use to torpor, roost-selection, and breeding ecology. Fishing and trawling bats also present unique conservation concerns: water quality impacts directly on both the availability and detectability of prey and the roosting behavior of these species is often constrained by the vicinity of suitable waterways. The Large-footed Myotis, *Myotis macropus*, is morphologically and ecologically similar to overseas trawling species, and is Australia's only trawling microbat. This review summarizes the current knowledge of the ecology of fishing and trawling bats and presents recent results on the feeding ecology, roosting behavior, and relatedness of *M. macropus* populations in southeastern Australia. In Queensland *M. macropus* forms harems and has two breeding seasons per year. There is also evidence of two birthing periods in southern Australia. *M. macropus* forages almost exclusively over water and preys upon aquatic invertebrates and fish. *M. macropus* roosts in a variety of structures located within 100 m of foraging grounds and shows preferences for distinct roost microclimates. Finally, despite the vagility of microbats, nuclear microsatellite markers reveal genetically distinct populations of *M. macropus* in southeastern Australia. The obligate relationship between *M. macropus* and permanent waterways warns of impeding conservation challenges in the face of ongoing climate change.

Seasonal Variation of the Male Reproductive Tract of the Fishing-bat *Myotis vivesi*, Menegaux, 1901 (Chiroptera: Vespertilionidae)

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The Mexican fishing-bat *Myotis vivesi* is an endangered endemic species, but very little attention has been paid to the study of its reproductive biology. We made morphological and histological descriptions of male reproductive organs in 35 individuals collected throughout the year in Partida Island in the Sea of Cortes. We found that the male reproductive tract lacks a seminal vesicle but presents a paired ampullary glands. Spermatogenesis occurred from February to October, with retrogression in November, and a period of inactivity during December and January. Changes in seminiferous tubule and germinal epithelium areas occurred in correlation with the spermatogenic activity. On November spermiation occurred and the area of tubular lumen was enlarged and filled with spermatozoa. Sperm were stored in the cauda epididymides in November and December. During December/February the interstitial tissue cells had increased, and accessory sex glands still remained enlarged. These observations suggest that copulation is occurring at this time of the year. Sperm had a total length of 56.6 ± 2.91 µ; its head had a characteristic spatula shape and was 4.05 ± 0.22 µ long and 1.67 ± 0.28 µ wide. The

penis had a grooved baculum located at the dorsal part of the distal extreme of the urethra. This os penis was 1.06 mm long and 0.47 mm wide. The reproductive cycle of the fishing-bat apparently involves asynchrony between primary and secondary sexual functions, which is typical of temperate-zone vespertilionids.

Vocal Communication in the White-winged Vampire Bat (*Diaemus youngi*)

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When isolated, bat pups across many species emit low frequency double-note calls, which act as individual signatures. In a few cases, mothers respond vocally with coordinated temporal precision. Such antiphonal calling is known only from maternal-infant situations in bats. In white-winged vampires (*Diaemus youngi*), however, double-note calls commonly occur among unrelated adults. These bats also respond antiphonally to playback. We therefore hypothesized that double-note function similarly as contact duets among adults. If so, a conspecific should precisely alternate calls and vocally discriminate individuals. We sampled structure and timing of double-note calls from 17 captive *D. youngi*. We hand measured temporal parameters, and extracted spectral parameters, including harmonic information, using new automated techniques developed from human speech processing research. Although intra-individual call variation was high, our discriminate function analyses correctly classified 77% of calls to individual (6.6% expected by chance). Most information was encoded in spectral features, but note durations and inter-note interval alone yielded greater than chance classification. To test for vocal discrimination by bats, we further conducted a habituation discrimination playback experiment. Results are forthcoming, but *D. youngi* seem unique among bats in their antiphonal interaction with playback.

Environmental Education: Program for the Conservation of Bats of Alagoas, Brazil

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The Foundation Amanaié, together with Quântica Center of Study and Research and the Andirá Brasil, developed a children’s program for bat conservation in Alagoas, Brazil. The program uses environmental educational activities to teach children about the importance of bats, their habitat, their behavior, and their benefits for the environment and mankind. The aim of the program is to recognize children’s perceptions about bats, identifying and demystifying possible prejudices children might have, and to divulge information about different aspects of bat ecology and behavior by educative dynamics in groups. Activities released at schools include the use of puppets, which represent several Alagoan/Brazilian bat species, scenarios of their habitats, posters, banners, and folders. Additionally, we perform play-activities with the aid of games like dominos, memory games, food-searching games, and the painting of masks with all Andirá’s Gang characters. The creation of the Andirá’s Gang characters was inspired by four bat species that are registered for Alagoas State and present distinct feeding behaviors: *Molossus molossus, Desmodus rotundus, Glossophaga soricina*, and *Artibeus lituratus*. Andirá’s Gang intends to clarify the importance of bats in reforestation of deforested areas, pollinization, and insect control. It is also our aim to educate about the threats bats are facing as a result of urban expansion, demonstrating that lack of knowledge about their ecology and behavior is the greatest impediment for their conservation. This program for bat conservation intends to promote public perception of the importance of this group of mammals and through this awakening, contribute to the conservation of bats and their habitats throughout the State and other regions of Brazil.

Checklist of Bats from the City of Maceio, State of Alagoas, Northeastern Brazil
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Bats represent one of the largest groups of wild mammals in tropical regions. The knowledge of their diversity, ecology, and biology is important for any study about the conservation and management of their populations. Our aim is to present a checklist of bats from the region of Maceió, State of Alagoas, northeastern Brazil. Maceio is the state capital with a population of 922,458 inhabitants, has an area of 511 km^2, is located at 7 m above sea level, and has an annual average temperature of 25°C. During 2006 and 2007, the richness and the relative abundance of bats were evaluated at four sites: urban area (a), cattle farms (b), Atlantic forest (c), and Maceio Coastal (d). A total of 140 bats were netted during 15 nights between 18:00 and 22:00 h. The most predominant species were *Molossus molossus* (40.0%; a, d), *Glossophaga soricina* (7.1%; a, d), *Platyrrhinus lineatus* (7.1%; a, d), and *Phyllostomus hastatus* (5.1%; d). Other trapped species were: *Phyllostomus discolor* (a, d), *Lophostoma brasiliense* (d), *Carollia perspicillata* (a, b, c, d), *Artibeus lituratus* (a, b, c), *Artibeus cinereus* (a, d), *Artibeus planirostris* (d), *Artibeus obscurus* (a, d), *Sturnira lilium* (a, d), *Desmodus rotundus* (d), *Peropteryx macrotis* (d), *Saccopteryx bilineata* (d), *Eumops glaucinus* (d), *Molossus rufus* (a, b), *Cynomops planirostris* (d), and *Myotis nigricans* (a, b, c), resulting in a total of 19 species belonging to the families Phyllostomidae, Emballonuridae, Molossidae, and Vespertilionidae. A low number of phyllostomine bats (three species) in Maceio is a good indicator of a high level of disturbance and most species were captured in the two most disturbed places: Maceio Coastal (84.2% of the bat species) and Urban Area (57.9%). More studies on bats should be initiated, so it will be possible to determinate the real diversity of bats in the state of Alagoas, northeastern Brazil.

Global Patterns of Bat Species Distributions: Environmental Determinants of Diversity, Hotspots, and Priority Areas for Conservation
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Geographic patterns of species distributions are at the core of much of ecology, biogeography, and conservation. Correlates and surrogates of richness patterns have been a major research focus, both to guide conservation in the absence of species-level data. Here I use distribution data of all mammals to investigate global geographic and environmental gradients of mammal richness across major constituent clades and the role of bats in these issues. Major results are as follows. First, estimates of productivity emerge as the most general cross-order predictor and are also by far the strongest predictor of total mammal species richness. Interestingly, bats are the strongest correlates of land mammal species richness. Second, a combination of rarity, anthropogenic impacts, and political endemism put about a quarter of bat species, and a larger fraction of their populations, at risk of extinction. A complementarity analysis for selecting priority areas for conservation shows that around 8% of Earth's land surface should be managed for conservation to preserve at least 10% of all bat species geographic ranges. Different approaches, from protection (or establishment) of reserves to countryside biogeographic enhancement of human-dominated landscapes, will be required to approach this minimal goal.

Comparative Social Structure of Spix's Disc-winged Bat, *Thyroptera tricolor*
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Studies of social organization in mammals have normally described the size, sexual composition, and spatiotemporal cohesion of a society, and many have focused their attention on the ecological and evolutionary processes that shape interspecific differences in social strategies. Few studies, however, have addressed the environmental influence on individual decision making, although intraspecific variation in social behavior can be expected in response to divergent ecological conditions and behavioral phenotypes. In this study we use Spix's disc-winged bat, *Thyroptera tricolor*, to determine if variation in social behavior occurs in response to differences in roost density. We searched furled leaves to locate roosting bats at five sites in and around the Golfito Wildlife Refuge, southwestern Costa Rica, twice per month for one year. Bats were captured and marked with individually-numbered wing bands, and group composition recorded. We compared patterns of association, group size, and group composition among bats sampled at all sites. Association indices were greater at sites with higher roost density, indicating that groups were more stable. In contrast, group composition was more labile in areas of low roost density, indicating extensive mixing of individuals from neighboring groups. In the few occasions in which variation of group composition occurred in areas with high roost density, groups experienced fission in two groups, which soon fused again. We rarely observed the arrival of new individuals into groups at these sites. Changes in group composition in areas of low roost density, however, occurred by constant fission and fusion of group members, by the arrival of new individuals, and by the permanent departure of individuals. Group size and group sex ratio did not vary significantly among sites. These results demonstrate that roost availability influences the social behavior of *Thyroptera tricolor,* particularly in regards to the stability of social groups.

Different Hunting Tactics Determine Different Patterns of Activity and Their Environmental Correlates in Temperate Insectivorous Bats
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Co-occurring insectivorous bat taxa exhibit different hunting tactics. That may cause interspecific differences in sensitivity to variation of food resources and other environmental factors. To test this, we studied spatio-temporal dynamics of activity in seven vespertilionid species in northern Poland, using broadband ultrasound detection and monitoring of their potential correlates. Six species (genera *Eptesicus*, *Pipistrellus*, *Nyctalus*) belonged to aerial hawkers and one (*Myotis daubentonii*) to water-surface foragers. Seasonal activity of *M. daubentonii* was bimodal with peaks in April and August-September. The highest flight activity of *Nyctalus*, *Eptesicus*, and *Pipistrellus* bats was recorded in midsummer. The cluster analysis of seasonal patterns reflected divisions based on hunting tactics but not on migratory behavior. Stepwise multiple regression models indicated that the prominent limiting factors for aerial

hawkers were biomass of potential prey and air temperature. Activity of *M. daubentonii* revealed no effect of the latter two factors but it was negatively affected by floating vegetation (that masks echoes of prey items), fog (that absorbs echolocation calls), and moonlight (that may increase predation risk). In canonical redundancy analysis (RDA), aerial hawkers were ordinated close to each other with food and temperature, while *M. daubentonii* occupied a separate position on a biplot. Moreover, division between aerial hawkers and water-surface foragers appeared in nightly activity rhythms. The first group in early summer exhibits two peaks of activity: at dusk and before dawn. Such bimodal patterns are known to reflect flight activity rhythms of crepuscular insects. The highest activity of *M. daubentonii* occurred at midnight, and the pattern did not change seasonally. Trophic resources appear to have no significance as a limiting factor for species using microhabitats with unusually high prey abundance (e.g., water surface). Activities of such species, however, may be more affected by temporally changing detectability of food items and vulnerability to predation pressure.

The Extra Genome of the Little Brown Bat (*Myotis lucifugus*)

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During the course of quality control on the recovery DNA sequencing practices a region of the cytochrome oxidase 1 (CO1) gene was repeatedly sequenced from the same specimen. The recovered sequences showed two distinct variants distinguished by two synonymous mutations. We used a variety of techniques to eliminate the possibility of non-functional nuclear copies of mitochondrial genes (NUMTs). Preliminary investigations suggest this may be a novel case of coding level sequence heteroplasmy, a known but rare phenomenon. Identical corresponding variants separated by an additional two synonymous mutations were recovered from cytochrome *b* sequences and the variants have been found in all tissue types. Known mechanisms of heteroplasmy—paternal transfer, post zygotic de novo mutations and mutational compensations—have been eliminated as possibly routs to this case of heteroplasmy. I will discuss the evidence for this genetic phenomenon, future ways to detect and confirm the observation, and present a novel mechanism that could account for this situation. Coding level heteroplasmy is generally assumed to be unstable and exceeding rare but may be maintained in some maternal bat lineages. This observation should be considered a biological rarity but will add to our knowledge of mitochondrial inheritance.

Geographic Patterns of Mitochondrial DNA Sequence Variation in Neotropical Bats

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Substantial increases in the amount and quality of sequence information deposited in public databases (GenBank, EMBL, DDBJ, BOLD) in combination with collateral information (voucher information, collection dates, GPS locations, etc.) represent a significant resource for many areas of research. In this study we use ~10, 000 mitochondrial sequences from GenBank and BOLD to explore the patterns of sequence variation within Neotropical bat species from 11 countries. We explore spatial distributions of haplotypes with respect to geographic distances and landscape features. We focus our investigation on several species for which previously identified patterns of phylogeography are available and provide comparisons between our study and previous analyses. Our results indicate that spatial distributions of sequence variation are not consistent between bat species and cannot easily be predicted. We also confirm a previously hypothesized range overlap between *Carollia brevicauda* and *Carollia sowelli* indicating that these two species live sympatrically within a restricted geographic area of Panama. Our research was possible due to the extensive collateral information available for some sequences (i.e., GPS co-ordinates and voucher information). We advocate the increased deposition of this information into public databases to facilitate future research.

A Method for Estimating the Relative Ranges of Bat Detectors

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One limitation of bat detector studies is that an indeterminate space is surveyed. Size of bat detector detection cones varies under different recording circumstances and among bat species with different call intensities. As a result, comparisons of bat activity across species, habitats, or bat detectors are confounded by the unknown detector range. We developed a method to calculate the range of detection cones using two aligned bat detectors. The distribution of detections between the two detectors is put into an algorithm to produce an estimate of the detector range. We tested the method, using both computer simulations and a field experiment. The computer simulations demonstrated that, given sufficient data, this method can precisely calculate the range of detection cones, if the detection probability equals 1. When the detection probability varies with the distance to the detector, the detector does not have a simple "range," but rather a series of distances and probabilities. In this case, our simple range estimate is a bit coarse, but still valuable because the range of each bat detector, relative to other bat detectors in the experiment, can be estimated for each recording circumstance (i.e., each species, habitat, etc). The field experiment confirmed the ability to precisely estimate the relative range of detection cones under field conditions. Because detection probability varied with distance in the field experiment, the range estimates are coarse, but an advancement over current methods.

Environmental Factors Influencing the Status and Management of Bats under Georgia (USA) Bridges

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During a period spanning August 2003 through April 2005, this research effort focused upon a random sample of 540 bridges located in 136 Georgia counties. Within this sample, 55 bridges were identified as currently or previously occupied by roosting bats. Numerous bridge construction and surrounding habitat characteristics of roost and non-roost bridges were compared in an effort to identify bat roosting preferences. Factors such as bridge construction techniques and materials, elevation of bridge, age of bridge, distances from water, surrounding habitat type, and presence or evidence of previous habitation by bat colonies were considered. The statistical analysis of the findings confirms results from previous studies dealing with the importance of bridges as bat roost habitats, especially for maternity colonies. The authors make recommendations to the Georgia State Department of Transportation on the conduct of maintenance and construction activities on bridges that will support existing and future bat use whenever possible. It further was recommended that, when demolition of a roost bridge is required, alternative roosting habitat should be provided in order to avoid displacing established bat colonies.

Classical and Molecular Cytogenetic Analysis of Meiotic Cells: Simple and Composite Neo-XX/XY System

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Classical and molecular cytogenetic analyses of sex chromosomes were carried out in mitotic and meiotic cells of Chiroptera species belonging to four Phyllostomidae subfamilies, with chromosomal sex determination systems of the simple, multiple, and combined types. Probes from whole chromosomes of *Carollia brevicauda* were developed in the Molecular Cytogenetics Laboratory, Department of Veterinary Medicine, University of Cambridge, UK (Pieczarka et al., 2005). The results obtained with multicolor FISH revealed that the species with a simple XX/XY system share homology between the X and Y sex chromosomes in the pseudo autosomal region (PAR). In both mitotic and meiotic cells, the main rearrangements responsible for the variation in the simple sex system of the Phyllostomidae family are the autosome-Xq and subsequent autosome-Yp translocations, which originated the multiple XX/XY_1Y_2 and the combined neo-XX/XY chromosomal sex determination systems. Using multicolor FISH in meiotic cells, it is possible to observe the independent behavior of the original XY and the neo-XY segments, observed in the sex chromosomes of some Glossophaginae and Stenodermatinae species with simple and combined systems, respectively. This behavior is probably due to the heterochromatic block (*Artibeus* and *Uroderma*) that blocks the inactivation diffusion effect to the autosomal region of the XY. We compared the meiotic behavior of the sex chromosomes in the two systems. This analysis shows differential condensation of the axes of the original X and Y when compared with the autosome-sex chromosomes. These data and the pairing between original X-Y segments (PAR) and A-X suggest gene activity in these regions during meiosis. Chromosome 15 of *Phyllostomus hastatus*, rearranged in Xq of *Artibeus cinereus* and *Uroderma magnirostrum*, represents a synapomorphy that is probably conserved in all species of the Stenodermatinae subfamily.

Sex Vesicle versus Sex Body: A New Analysis of XY_1Y_2 Meiotic Behavior in *Carollia* by Chromosome Painting

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Classical and molecular cytogenetic analyses of sex chromosomes were carried out in mitotic and meiotic cells of *Carollia* species from the Phyllostomidae (Chiroptera) family with XX/XY_1Y_2 multiple-type sex determination systems. The results revealed that the species *Carollia perspicillata* and *Carollia brevicauda* share homology between the X and Y sex chromosomes. In both mitotic and meiotic cells, the main rearrangements responsible for variation in the simple sex system of *Carollia* are autosome-Xq translocations. Probes from whole chromosomes of *Carollia brevicauda* were developed in the Molecular Cytogenetics Lab., University of Cambridge, UK. Using these probes as multicolor FISH in meiotic cells, it was possible to observe the independent behavior of the original XpY_1 and the XqY_2 segments, probably because of the presence of the nucleolus organizer region that blocks the inactivation diffusion effect to the autosomal region of the X. A new analysis of the meiotic behavior of the sex chromosomes, here named sex body, is described; variations in the condensation of the differential axes of the original X and Y and autosome-sex chromosomes are compared. The pairing between original X-Y segments (Pseudo Autosomal Region) and A-X is described, suggesting gene activity in these regions during meiosis.

Automated Acoustic Identification of Nine Bat Species of the Eastern United States

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Increased sophistication in the methodology and technology used to monitor echolocating bats continues to widen the available options to meet research and management objectives for bats. We developed and tested an automated program for detecting, measuring, and classifying species of bat echolocation calls. We analyzed 584 echolocation sequences from nine bat species of the eastern United States (*Lasiurus borealis*, *Myotis austroriparius*, *M. grisescens*, *M. leibii*, *M. lucifugus*, *M. septentrionalis*, *M. sodalis*, *Nycticeius humeralis*, and *Pipistrellus subflavus*). A base set of 11 variables was measured automatically and manually, and an additional 28 variables were measured automatically as a part of the full variable set. Species were classified with Discriminant Function Analysis (DFA) using each variable set and measurement method with both a single DFA and a hierarchical set of DFAs that classified genus level before species level. Classification rates were also summarized for a subset of the sequences with Discriminant probabilities > 0.75. Overall classification rates were 67.6% for manually measured base variable set, 63.0% and 68.3% for automatically measured base and full variable sets, respectively, and 84.4% for the 62.5% of calls with Discriminant probabilities > 0.75 using the automatically measured full variable set. Hierarchical classification improved overall classification rates by < 2% for base variable set classifications and 6.9% for the automatically measured full variable. Hierarchical classification worked synergistically with a large variable set to increase classification rates. Six of nine species had overall classifications of 93.3–100% with the best classifier. Also, six of nine species had higher classification rates than that achieved in previous studies. Automated call processing is a fully objective and repeatable method requiring less cost, time, and user expertise than manual methods, especially for large datasets.

Cloning and Characterization of the First Cytokine Genes from a Bat Species

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Bats represent one fifth of the nearly 5,000 known species of mammals. In recent years, bats have been identified as reservoirs and possible reservoirs for several important human viruses, including Nipah virus, Hendra virus, SARS coronavirus, and Ebola virus. Little is known about how the immune system of bats engages viruses, nor how these viruses might evade sterilizing immunity. We have initiated a project to develop immunologic methods in two bat species, *Carollia perspicillata* (Seba's Short-tailed Fruit Bat) and *Artibeus jamaicensis* (Jamaican Fruit Bat), from which Nepuyo and Tacaribe viruses have been isolated. Our initial work has focused on the cloning of cytokine genes, and we have succeeded with a full-length clone of tumor necrosis factor (TNF), and partial cDNA clones of interleukin-10 (IL-10), Interleukin-23 (IL-23), and granulocyte macrophage-colony stimulating factor (GM-CSF). We have also cloned several immune-related transcription factors, including STAT4, STAT6, and T-bet, Fox-p3, which control the expression of some cytokine genes. To our knowledge, these are the first cytokine and cytokine-related genes cloned from any bat species.

The Effects of Urbanization on Bats in the Prairies of Southern Alberta
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Urban ecology research lacks studies on bats, particularly in the grasslands of North America, where bats are less diverse than in other biomes due to the relative lack of habitat complexity. I am comparing bats inside and outside prairie cities, investigating my hypothesis that urbanization benefits prairie bats by creating structurally complex islands in a relatively homogeneous landscape, in which roost and prey availability are increased and the urban heat-island effect reduces use of torpor. My predictions are: 1) urban bats are more speciose and abundant; 2) urban bats have higher levels of feeding activity; 3) urban bats are in better body condition; 4) urban populations contain greater proportions of reproductive individuals; 5) urban females give birth earlier and their pups grow more quickly; 6) urban populations contain greater proportions of volant juveniles; and 7) urban populations contain greater proportions of one-year olds (due to greater overwinter survival). I am working at urban and non-urban riparian sites where I acoustically monitor bat activity, capture bats to assess community composition, population age structure, and individual fitness, and dissect fecal pellets to assess diet. To compare insect availability and roost temperature between urban and non-urban areas, I sample nocturnal insects and record the temperature of maternity roosts. Capture data from 2006 indicate the presence of at least six species in my study area. Urban and non-urban habitats had equal species richness, but species evenness was higher in non-urban areas. The most commonly encountered bat in all sites was *Myotis lucifugus*. For *M. lucifugus*, relative to non-urban conspecifics, urban adult females were in poorer body condition, yet gave birth earlier, while urban adult males underwent spermatogenesis later. Acoustic data from 2006 reveal no differences in activity between urban and non-urban areas. Results from 2006 and 2007 will be presented.

Fossil Bats from Atapuerca, Burgos, Spain
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Atapuerca is recognized as one of the most important archaeological sites in the World, accounting for at least three different species of human beings within the genus *Homo* in a time range of one and a half million years from present. The site is formed by several caves in the Sierra de Atapuerca, near Burgos, Spain, and besides the important hominid fossil record, there is a very diverse and abundant mammal fauna, from shrews to elephants. Fossil bats are part of small mammal remains, presently accounting for 55 taxa, including rodents, insectivores, and rabbits. Bats are the less abundant of the mammalian remains due to their delicate bones, difficulty in preservation, and the fact that they do not accumulate by the action of predators but rather by the natural accumulation of dead animals. Bat remains can be found in caves where there are important reproduction colonies. Therefore in Atapuerca, as in many caves, fossil deposits have their share of bat bones, many corresponding to currently living species in the cave, but others are from species that no longer occur in the region. The bat species recognized to date in Atapuerca are: probably two *Rhinolophus* species, one *Myotis* species, and the small cave bat *Miniopterus schreibersi*. They occur mainly in two of the six Atapuerca localities: Gran Dolina—dated between 900 and 250 Ky B.P.—represents one of the best Pleistocene sections in Western Europe, and Chiroptera are present nearly all along the sequence, with *Myotis* the most abundant taxon. The other locality, Sima de los Huesos, has an important number of fossil bat remains because it is deeper within the Atapuerca karst system. Bat faunas range between 600 and 200? Ky B.P. Further specific study of the Atapuerca bat remains is warranted to detail past paleoenvironments based on such fauna.

Merging Historical and Ecological Biogeography for the Short-faced Bats

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Phylogenetic inference suggests that several groups of bats, and at least two groups of plants and anole lizards, colonized the mainland of tropical America after evolving in the West Indies. Since the 1960s, when the equilibrium theory of island biogeography was introduced, ecologists have proposed that competitive disadvantage thwarts colonization from islands to continents. If this were the case, then species of Caribbean origin would be marginal in continental ecosystems. To test this hypothesis we modeled the niches of short-faced bats (subtribe Stenodermatina) based on about 1,000 locality records, and used molecular phylogenies to reconstruct ancestral distributions. We did not find an evolved limit to competitive ability that would marginalize short-faced bats from species-rich continental communities. Instead, geological history appears to account for successful oceanic dispersal in this group. We caution that other groups of Caribbean origin might yet display limited competitive ability, because we cannot a priori expect niches to evolve in a similar manner across separate radiations. The combination of environmental niche modeling and phylogeny-based reconstruction of ancestral distributions holds great promise for testing ecological hypotheses in a synthetic way.

Natalid Dispersal with Conserved Niches

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Molecular and morphological phylogenies strongly support a West Indian origin for all extant natalids. Dispersal from the islands to the continent should imply a shift in ecological niche, as continental ecosystems are more complex than insular ones. Niche conservatism, however, seems to be the norm in most organisms studied to date. We modeled the distributions of extant natalids based on more than 500 locality records and used molecular phylogenies to reconstruct ancestral niches in this family. We found no link between dispersal and abrupt niche shifts. Rather, the geological history of the Caribbean enabled range expansion without radical departures from ancestral niches. Our results suggest that biogeographic models focused exclusively on vicariance vs. dispersal, or purely mechanistic explanations for species distributions, are misguided. Instead, the combination of environmental niche modeling and phylogeny-based reconstruction of ancestral distributions signals a new approach. This synthetic biogeography recognizes both the unique features of individual species and the importance of ecosystem changes that shape entire biotas.

Dispersal in Tropical Bats: When All Offspring Have to Leave

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When looking at dispersal in bats, one must remain aware of the fundamental differences between bats of the temperate and tropical zones. In contrast to the temperate zone, year-round social groups can be maintained in the tropics and this significantly affects dispersal decisions of the offspring. We investigated offspring dispersal and local population structure in the Neotropical bat *Lophostoma silvicolum.* The mating system of this species is resource defense polygyny, with the resource being active termite nests, excavated by single males, which are then joined by females. We combined field observations of 14 harems during three years with data about the genetic structure within and between these groups, calculated with one mitochondrial and ten nuclear microsatellite loci. The results show that both male and female offspring disperse before maturity. In addition, we estimated lifespan of excavated termite nests and the duration they were occupied by the same male. Our findings suggest that long male tenure of roosts is the most likely cause for dispersal by female offspring that can reach maturity at a low age of 6 months. The reason for male dispersal is probably to gain access to breeding partners. These findings are discussed in the context of what is known about dispersal in other species of tropical bats: is female and thus all-offspring dispersal more typical in bats than previously assumed?

The Environmental Interpretation as a Tool for Bat Conservation

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Interpretation is a communication tool designed to enrich and simplify the quality of a visitor experience and to inspire an appreciation for the environment in a pleasant way. A key for the good application of the interpretation is the guide, who should be able to share unique and fascinating stories and show passion and experience for the resource we need to conserve. In the case of bat conservation, the guide should develop consciousness in the people and help eliminate the effects of the extermination campaigns that have threatened bats in the recent past, and counteract prejudices, wrong ideas, and generalized myths. Here I present a case study of the Xoxafi Grotto, located in Hidalgo Mexico. This cave holds six bat species, three of which are migratory (*Leptonycteris curasoae*, *Leptonycteris nivalis*, and *Choeronycteris mexicanus*) and are considered Threatened under Mexican law. We implemented a course for all personnel is working in Xoxafi cave, from which they learned basic information about bats, developed activities and games, and learned the basic tools to become good environmental interpreters. These tools will help them start building capacities as guides, so visitors start learning about and recognize the value of Xoxafi Grotto as well as the bats that populate the cave—which in the end will benefit bats and their conservation.

Who's Who from Poos Clues: Designing Molecular Methods for the Study of Long-tailed Bat Ecology and Population Structure

Andrea Dekrout, Tim Lowe, Ray Cursons, Dick Wilkins, Stuart Parsons, and Bruce Clarkson; University of Auckland, New Zealand

New Zealand long-tailed bats (*Chalinolobus tuberculatus*) have been identified as a species vulnerable to extinction in the medium term. Their populations are, therefore, in need of management. Knowledge about the structure and dynamics of *C. tuberculatus* populations is a fundamental requirement for formulating management decisions. Historically such information has been difficult to obtain for cryptic, nocturnal species such as *C. tuberculatus*. Recently, researchers have started to overcome some of these difficulties by remotely monitoring species through their droppings. Monitoring fecal steroid hormone profiles for assessing testicular, ovarian (reproduction), and adrenocortical (stress) hormone activity is now a standard method, widely applied to many mammal species. More recently, non-invasive genotyping of mammals using DNA obtained from droppings has presented researchers the opportunity to identify individual animals and compare populations of cryptic species. However, conservation managers require information on both the genetic and the reproductive status of the individuals in a population. One published study does report splitting a large otter scat in two, to extract fecal hormones from one portion and fecal DNA from another portion. However, *C. tuberculatus*, like all microchiropterans, are small animals, weighing approximately 10 g. Such animals produce small droppings not conducive to splitting. We describe a simple, cost effective method for the extraction of both hormones and DNA from a single, small (2–10 mg) fecal pellet. We also describe the development and validation of fecal sex-steroid quantification and fecal micro-satellite DNA analysis for *Chalinolobus tuberculatus*.

"One Sex In The City (?)"—Indications of an Extreme Sex Bias in the Use of City Habitats by Bats in Hamilton New Zealand and the Ecology of Long-tailed Bats at the Urban-Rural Interface

Andrea Dekrout and Stuart Parsons; University of Auckland, Auckland, New Zealand

The endemic New Zealand Long-tailed Bat (*Chalinolobus tuberculatus*) is considered to be in population decline. This decline has been linked to anthropogenic land developments (such as urbanization), which are ever more reducing wildlife habitats. However, a number of species, including *C. tuberculatus*, are able to exploit modified areas. It has been suggested that encouraging bats to use urban areas can significantly contribute to the conservation of threatened species and extend their geographic range. Information on the ecological needs of urban species, such as *C. tuberculatus*, is need for urban planners to integrate wildlife management needs into land development such that wildlife may be conserved across a wide range. The distribution, habitat use, and behavior of an urban population of *C. tuberculatus* in the city of Hamilton, New Zealand have been investigated. This study has verified the presence of *C. tuberculatus* in Hamilton. Ultrasound survey methods for investigation of their range and distribution within Hamilton and at the urban-rural interface will be described and results will be presented. Further, a number of urban bats have been captured and the sex, reproductive status, morphometrics, and weight of these bats were recorded. Despite considerable trap effort only two female bats have been captured within the city; these represent less than one percent of the total bat captures. Twelve bats, including the two females, were selected to be marked with small (0.5 g) radio-transmitters and the ranges, habitat use, and time budgets of the bats were recorded. The ranges and nightly time budgets of Hamilton's *Chalinolobus tuberculatus* will be presented and potential reasons for the extreme sex bias towards captured males will be discussed.

Monitoring Long-tailed Bat (*Chalinolobus tuberculatus*) Populations: "One Poo Will Do"
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Chalinolobus tuberculatus have been identified as a species vulnerable to extinction. Knowledge about the structure and dynamics of *C. tuberculatus* populations is a fundamental requirement for formulating management decisions. Often information about bat populations comes from mark-recapture programs in which animals are trapped and marked at first capture. However, mark-recapture programs require a considerable input of resources and the results are often unreliable and do not reveal subtle changes in population health. Consequently, a new, remote monitoring tool, based on monitoring fecal hormone profiles and extracting and amplifying fecal DNA, is being developed for *Chalinolobus tuberculatus.* Monitoring hormone profiles through the use of fecal steroid assays offers a non-invasive method for determining sex ratios and assessing reproductive activity, while fecal DNA technology allows individuals to be identified and their relatedness to be determined. The potential application of this integrated method will be presented together with the method development and early results.

Morphological and Morphometric Analyses of *Platyrrhinus lineatus* (E. Geoffroy) and *Platyrrhinus recifinus* (Thomas) (Phyllostomidae, Stenodermatinae) from Southeastern Brazil
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Platyrrhinus lineatus and *P. recifinus* are morphometrically and morphologically similar. In order to verify the most efficient characters for discrimination of these sympatric species, we carried out morphological and morphometric analyses, using somatic and skull characters of 74 specimens of *P. lineatus* (n = 46) and *P. recifinus* (n = 28) caught in the states of Rio de Janeiro and Espírito Santo. Multivariate approaches using principal components (PCA) and discriminant function (DFA) analyses were used to compare species. These taxa can be distinguished using combinations of cranial and external characters. The first two principal components (PCA), as well as first and second canonical variables (CV) of DFA, split *P. lineatus* and *P. recifinus*, without overlapping. The forearm length (FA) and postorbital breadth (PoB), with high positive correlation in relation to CV1 and low negative correlation in relation to CV2, split *P. lineatus*. The basal length and mandibular length, with high negative correlation to CV1 and high positive correlation to CV2, split *P. recifinus*. Thus, *P. lineatus* and *P. recifinus* can be externally distinguished in size, where *P. lineatus* (FA 44.20–52.26 mm) is larger than *P. recifinus* (FA 40.44–43.84 mm). Qualitative differences were also found in: post-orbital processes (well developed in *P. lineatus*, poorly to moderately developed in *P. recifinus*); paraoccipital processes (well developed in *P. lineatus*, poorly developed in *P. recifinus*); fossa on the hypoconal basin of P4 (shallow in *P. lineatus*, deep in *P. recifinus*); stylar cusp in lingual cingulum on the base of the M1 metacone (present in *P. lineatus*, absent in *P. recifinus*); lingual cingulum of the M2 metacone (continuous to the paracone with notch in *P. lineatus*, continuous without notch in *P. recifinus*); m1 metaconid (well developed in *P. lineatus*, absent in *P. recifinus*); and lower incisors (distinctly bilobated in *P. lineatus*, poorly trilobed in *P. recifinus*). The characters related to the size and disposition of the upper incisors had shown great intraspecific variation, not being used in the distinction of them.

Demography Down Under: A Study of Population Age Structure and Effects of Mortality Sources on Grey-headed Flying Fox Population

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The Grey-headed Flying Fox (GHFF), *Pteropus poliocephalus*, is endemic to the east coast of Australia. Despite its wide distribution and perceived increase in numbers in urban areas, the species has been listed as vulnerable nation-wide. This listing is a direct result of a reported population decline of up to 30% in the past decade, from more than 560,000 animals in 1989 to more recent estimates of approximately 400,000 (these data were obtained by fly-out counts and should be regarded as estimates of abundance rather then precise population counts). Possible causes of this decline have been attributed to habitat clearance and modification for urban development and agriculture, human interference (e.g., disturbance at roosting sites, unregulated shooting, and erection of electric and barbed wires), and competition and hybridization with the Black Flying Fox (*Pteropus alecto*). More recently, increased mortality from heat events has also been reported. However, these causes remain largely unsubstantiated and at present the research to quantify their effects on population growth rates is limited. Additionally, GHFFs are seasonal breeders, with females giving birth to a single young each October/ November after a six-month gestation. Pups are highly dependant and are not weaned before about 6 months following birth. Thus, flying foxes are believed to have a low reproductive rate and high maternal investment, both indicative of relatively long-lived animals with low natural mortality rates. Nonetheless, current knowledge on age-based population parameters is speculative. This is the first study to accurately age both live individuals, as well as a sample of animals that have died from a range of causes. Thus, population age structure, recruitment rates, age at first reproduction, and longevity are explored. In addition, we quantify the effects of different mortality sources on the population and hope that this study can provide a baseline for future research and management of *P. poliocephalus*.

Conservation and Phylogeography of the Endangered Lesser Horseshoe Bat (*Rhinolophus hipposideros*)

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During the last glacial maximum (approximately 20,000 years ago), much of Northern Europe was covered in vast sheets of ice. Few animals survived in situ in pockets that were ice-free. Most populations either went extinct or migrated south to areas known as glacial refugia. Phylogeographic studies based in Europe have very often not included samples from Ireland. The origins of Ireland's populations are largely unknown, as are the means by which they arrived. Studies that have included Ireland have revealed a variety of colonization routes. This finding has implications for conservation management plans. Over a quarter of Ireland's terrestrial mammal species are bats. All but one are in the family Vespertilionidae. The remaining one is in the horseshoe bat family Rhinolophidae, and is the lesser horseshoe bat, *Rhinolophus hipposideros.* Though this bat has a wide geographic range, its populations are contracting and becoming extinct in Europe. Ireland has one of the largest populations of this species. However, the phylogenetic relationship of Ireland's population and the remaining European colonies is unknown. Samples are being obtained from Ireland and Europe, from which mitochondrial DNA, a Y-intronic region, and microsatellites are being amplified. From these data, a population genetic phylogeny will be generated. Ecological and acoustic data are being collected to support the findings.

Flying Fox Abundance Thresholds are Critical for Seed Dispersal on Pacific Islands
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Seed dispersal is a critical process in forest dynamics. The guild of seed-dispersing animals on Pacific islands is naturally depauperate because of island isolation, and has been further depleted by the extirpation and extinction of native vertebrates following human colonization. On some islands, flying foxes (Pteropodidae) are among the last remaining frugivores capable of dispersing large seeds. However, their effectiveness as dispersers has been hypothesized to depend on flying fox population densities being high enough to cause aggressive interactions among foraging individuals in fruiting trees. In Tonga (Polynesia), we quantified the proportion of seeds that *Pteropus tonganus* dispersed beyond the canopy of fruiting trees, over a range of sites that differed in flying fox abundance. The relationship between ecological function (seed dispersal) and flying fox abundance was non-linear and consistent with the density-dependence hypothesis. For most trees in sites below a threshold abundance of flying foxes, the animals dispersed < 1% of the seeds they handled. Above the threshold, dispersal away from trees increased to 58% as animal abundance approximately doubled. Hence, flying foxes may cease to be effective dispersers long before becoming rare. We also found that the abundance of fruiting trees places an upper limit on flying fox abundance. Given the interdependence of flying foxes and forest trees, long-term conservation of flying foxes may be possible only if they are maintained at densities great enough to continue their ecological role in forest dynamics.

The Ecomorphology and Mechanics of Feeding in Phyllostomid Bats: A Review and Synthesis of Future Directions
Elizabeth R. Dumont, UMass Amherst, USA

Bats are best known among biologists for their spectacular taxonomic and morphological diversity. Roughly one quarter of living mammal species are bats, and they arguably possess the greatest range of dietary adaptations of any mammalian order. A fundamental question in bat biology is; what kinds of mechanisms have shaped the evolution of the group? Many talented researchers have approached the question of speciation in bats using historical data, biogeography, ecology, behavior, and genetics. The field of ecomorphology is a relative newcomer to this mix. Ecomorphologists seek to interpret morphological diversity in the context of performance, which is specifically defined as an individual's ability to execute a task that presumably impacts fitness. Most ecomorphological research with bats has focused on bite force as a measure of feeding performance, and these studies are beginning to demonstrate intriguing patterns of variation among species. An important caveat of ecomorphological studies is that they address correlations between performance and morphology, not necessarily the mechanisms that underlie those associations. One relatively new approach to documenting mechanistic links between form and function is a modeling technique called finite element analysis (FEA). By combining morphological and behavioral data in controlled experiments, FEA can begin to unravel links between morphology and behavior that may have played a role in diversification. This presentation reviews and presents new data on feeding performance and the underlying feeding mechanics of New World leaf-nosed bats (Family Phyllostomidae)—a group that is particularly well suited to these kinds of inquiries.

Who's Hot and Who's Not: Torpor along a Latitudinal Gradient
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Torpor is a controlled suppression of metabolic processes that reduces energy expenditure. Environmental conditions vary with latitude during winter so it is reasonable to predict there will be variance in the physiology of torpor among populations from different geographic areas. My goal was to measure intraspecific variation in thermal energetics in big brown bats (*Eptesicus fuscus*) and eastern red bats (*Lasiurus borealis*) to determine whether there is a continuum based on different climates found across latitudinal gradients. I sampled bats from populations near the northern and southern limit of each species' winter range. I measured oxygen consumption and skin temperature of torpid bats over a range of temperatures to assess metabolism. Preliminary data suggest that mass-specific metabolic rate in big brown bats was affected by both ambient temperature and sex and varied with latitude. Bats from southern populations have higher torpid metabolic rates at cooler temperatures and lower torpid metabolic rates at warmer temperatures than do individuals from northern populations. Mass-specific metabolic rate in red bats was affected by ambient temperature, although a small sample size likely masked the influence of other parameters measured. Body temperature in both species approximated ambient temperature and the difference between these was greatest at 1–2°C in both species. Understanding winter requirements of hibernators will allow management efforts to account for changing environmental conditions and improve our ability to mitigate future threats to ecological systems. Considering energetic constraints will likely be useful in explaining seasonal distribution patterns, range expansions, and potential shifts in timing of life-history events.

Visitation of Nectar-feeding Bats to Blooming *Agave palmeri* in New Mexico
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Visitation of nectar-feeding bats to blooming *Agave palmeri* was studied in southwestern New Mexico in summer 2006 and 2007. *Agave palmeri* is the only known food source of federally endangered *Leptonycteris curasoae* and *L. nivalis* in New Mexico, but the feeding behavior of the bats has not formerly been studied there. Visitation was recorded using a Sony video recorder with NightShot, supplemented by infrared lighting. Results will be discussed.

The Environmental Education Experience of the Program for the Conservation of Mexican Bats
Cristina Espinosa, Laura Navarro, Ma. Luisa Franco, and M. Jesús Teniente; Bioconciencia, Bioconservación Educación y Ciencia A.C., Mexico

Over the last 13 years, the Program for the Conservation of Mexican Bats has been working with environmental education programs, and to bring people who live close to high-priority refugees/caves of endangered bat species tools for their participation in bat conservation. This experience has created one of the most important initiatives for bat conservation in Mexico, and perhaps Latin America. We apply our six different programs with children in the rural communities of Mexico according to the bat species we need to conserve, and we also approach schoolteachers, local authorities, women, and cave guides. We have created programs, according to the different feeding habits of bats, that have been implemented in at least 12 states of Mexico. We have created seven bilingual children stories, designed games and activities with bats as the subject, created an itinerant exhibit that has been placed in at least 30 places around Mexico, and created radio spots with bat stories that have received international awards. The principal species we are protecting through our environmental education efforts at the moment include: *Tadarida brasiliensis*, *Leptonycteris nivalis*, *L. curasoae*, and the endemic flat-headed bat *Myotis planiceps*. But most importantly our work translates into efforts to reduce the myths that are very deep-rooted in the Mexican Culture, and by doing so, benefit bats.

Effects of Forest Fragmentation on Aerial Insectivorous Bats in Panamá Assessed with Acoustic Monitoring

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It is well known that habitat disturbance and fragmentation leads to a decline of species richness and modification of ensemble structure of New World leaf-nosed bats (Phyllostomidae). However, the effects of forest fragmentation on other Neotropical bats, namely aerial insectivores, are poorly understood, despite the high diversity of this ensemble. Here we used acoustic monitoring for comparison of diversity, structure, and activity of aerial insectivorous bats on a set of land-bridge islands in Gatún Lake, Panama. Eight islands, representing two size classes and two degrees of isolation, and six sites in continuous mainland forest (three forest edge and three forest interior sites) were sampled between March and June of 2006. Bats were surveyed on transects conducted for 4 hours after dusk resulting in > 11,800 bat passes from 83 hours of recording. Overall, contrary to expectation, islands harbored richer ensembles, revealed higher relative activity, and showed more capture attempts than continuous forest sites. Species richness estimators were similar to observed species richness, but small islands harbored fewer species than expected. Bat ensemble structure did not differ between study sites' categories, neither when rank abundance curves were compared, nor when analyses of similarity were performed. Non-metric multidimensional scaling revealed no distinct clustering of sites or species, and when environmental variables were fitted onto the ordinations no correlations were found. Nonetheless, some high flying species, like *Molossus* spp. and *Diclidurus albus*, were close in the ordination. Tolerance to fragmentation was prevalent in the majority of species, but few were only found in mature forests, as expected. Our results demonstrate, with very few exceptions, that small fragments are well used by aerial insectivorous bats and provide effective foraging grounds, even after severe fragmentation, underscoring the adaptability potential of this ensemble.

The Behavioral Responses of Microbats to their Ectoparasites

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All mammals carry with them organisms that depend on their host for survival. The diversity and abundance of these parasites can vary considerably on an individual host over time. These

fluctuations may be influenced by the physiological, behavioral, or environmental conditions imposed by the host. Conversely, the parasites themselves may affect their host through reduced reproductive fitness, health, and behavioral changes. We are studying the ectoparasites of two species of Australian microbat, Gould's Wattled Bat (*Chalinolobus gouldii*) and the White-striped Free-tailed Bat (*Tadarida australis*), and the influence of ectoparasites on the roosting behavior of their hosts. A total of 296 tagged bats and 26 artificial roosting boxes have been monitored for parasites each month for the past two years. Although commonly found sharing roosts, these two species of bats differ significantly in the type and load of parasites they carry. *C. gouldii* carry ticks, mites, and bat flies, of which one species of mite, *Spinturnix novaehollandiae* and a bat fly, *Basilia troughtoni*, are not found on *T. australis*. Experimental inter-specific parasite transfers revealed that these two parasites do not recognize *T. australis* as a host. Parasite loads vary seasonally, with *S. novaehollandiae* and *B. troughtoni* appearing to time reproductive effort with that of their host. When parasite loads were experimentally increased on *C. gouldii* we observed an increase in grooming behavior, which suggests the parasites incur an energetic cost to their host. Like many tree-hole roosting bats, *T. australis* and *C. gouldii* frequently shift roost sites, a behavior that may reduce their ectoparasite load and the associated costs. Most bat parasites have at least one life stage in the roost. Therefore it is theoretically possible that by vacating roosts the bats could disrupt the life cycles, slow parasite reproduction, and thereby reduce their parasite load. By experimentally manipulating parasite loads, this study provides a greater understanding of the effect of microchiropteran ectoparasites on the roost shifting behavior of their hosts.

Skull Shape Diversity in the *Myotis myotis-blythii-punicus* Species Complex: Taxonomic Implications and Fossils Assignments

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The large *Myotis* species complex occurs in the West Palearctic region. Traditionally this complex was divided into two biological species: the Greater Mouse-eared Bat, *Myotis myotis*, and the Lesser Mouse-eared Bat, *Myotis blythii*. However, recent molecular investigations revealed a third taxon, the Maghrebian Mouse-eared Bat, *M. cf. punicus*, living in allopatry in North Africa, Corsica, Sardinia, and Malta. *M. myotis* and *M. blythii* were thus restricted to Eurasia. Currently, there is no morphological character that would allow the differentiation of *M. cf. punicus* from *M. blythii omari* living in the East Mediterranean region, and thus it remains unclear whether these two taxa belong to a single species or not. To shed light on this question, the variability in size and shape of the skull within this complex was explored using powerful 3D landmark-based geometric morphometrics methods. Three morphological groups were apparent and congruent with their current taxonomic assignment into the three species. *M. punicus* and *M. blythii omari* were clearly differentiated, a result that favors the assignment of a specific rank to *M. punicus.* The presence in the Palearctic region of three species instead of two and high variability within some species require a new interpretation or re-interpretation of several data, including historical ones. The geographic variability within *M. punicus* was further explored. The skull of Corsican and Sardinian specimens significantly differed from that of Maghrebian ones, suggesting the existence of further cryptic taxonomic diversity. In this new morphological framework, several fossils of large *Myotis* were included in the analysis for a species assignment.

This analysis allowed a formal test of several biogeographic hypotheses about the evolution of this complex in the West Mediterranean region.

Phylogeography of the Greater Horseshoe Bat, *Rhinolophus ferrumequinum*: Lessons from Using Different Markers

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The impact of glaciations on the distribution, genetic structure, and diversity of populations is well established. In Europe, the main refugia identified are Italy, Iberia, and the Balkans. However, most studies do not sample beyond Europe even when the species range is much wider, potentially leading to an ascertainment bias. Furthermore, phylogeographic studies are typically based on haplotype data, occasionally on nuclear markers such as microsatellites, but rarely combine multiple markers. This is unfortunate because the use of markers with contrasting modes of inheritance and rates of evolution might provide a more accurate and comprehensive understanding of a species' history. Here we present a detailed study of mtDNA and microsatellite variation in the greater horseshoe bats, sampled from across its Palearctic range. We show that the phylogeographic signals obtained from the two markers are different and that only by combining the datasets are we able to reconstruct the species history through multiple glacial periods, and assess the relative importance of European versus Asian refugia.

Phylogeography and Demographic History of *Myotis vivesi* (Chiroptera: Vespertilionidae) from the Gulf of California, Mexico

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The fishing bat *Myotis vivesi* is an endemic species of the islands of the Gulf of California, Mexico. Habitat modification and the introduction of exotic fauna have lead to an apparent contraction of it historical distribution range and it has been listed as a threatened species in the Mexican law. In the present work, partial mitochondrial cytochrome *b* sequences (134 individuals) from 11 colonies of *Myotis vivesi* were used to assess their genealogical and demographical histories. Haplotypic diversity, nucleotidic diversity, probability of occurrence of bottlenecks, population-genetic structure, and genealogical relationships among populations were estimated. A 282 bp amplicon was obtained. Tajima neutrality test showed that the fragment does not have a selective value ($D = -1.06090$, $p > 0.05$); total number of haplotypes was 39. Haplotypic diversity (h) ranged from 0 to 0.9843, while nucleotidic diversity (π) ranged 0 to 0.01656. SAMOVA detected three main groups: one group consisted of 9 of the 11 colonies, and two colonies represented unique populations (FCT = 0.3450, $p = 0.016$). Harpending index and sum of the squared deviations (SSD) cannot detect the presence of bottlenecks in any of the three groups. Correlation between geographic distance and F_{ST} values suggests a stepping-stone model ($R^2 = 0.52$). Finally, one of the haplotypes showed a high frequency (46.2%) and it was present in all colonies. Haplotype network suggests a rapid population expansion (derivate haplotypes with low frequencies) without a bottleneck. The present work is part of a more extensive project to establish a conservation program for this species.

Use of DNA Barcodes to Understand Southeast Asian Bat Diversity
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We sequenced DNA barcodes (655 base-pair segments of the cytochrome *c* oxidase subunit I gene) from ~1,900 specimens of approximately 165 species of bats from Southeast Asia and southern China to determine their utility for discriminating and identifying species. In common with previous studies on vertebrates (e.g., birds in North America and bats in Guyana), the majority of specimens identified as morphologically or acoustically distinct species based on classical taxonomy could be discriminated using DNA barcodes, with the apparent exception of three species pairs. Also in common with previous studies, there were many cases (particularly within genera *Kerivoula*, *Murina*, *Rhinolophus*, *Hipposideros*, and *Myotis*), where DNA barcodes revealed multiple lineages with deep divides within putative morphological species; in some cases specimens supposedly of the same species were not each other's nearest neighbors. This indicates that species diversity within the region may be substantially underestimated, with DNA barcodes serving as a useful tool to identify areas in need of focused taxonomic research. However, unlike the situation in North American birds, there was also considerable geographic structure to the data set. Nearly all species with samples from widely disparate geographic areas (e.g., Borneo and Peninsular Malaysia, or Peninsular Malaysia and Laos/Vietnam) showed a geographically structured pattern of genetic distances, though usually less than differences between recognized species in the same genus. This suggests limited mtDNA gene flow across the region. However, mtDNA sequence differences alone are not sufficient to indicate species status. Further analyses using morphological and acoustic data, as well as genes with a different inheritance mechanism and rates of mutation will be necessary to determine whether the populations are differentiated in other ways. If they are distinct, an additional challenge will be to determine whether species or subspecies concepts are most appropriate to recognize this type of geographic variation.

The PCMM and the BENM for Bat Conservation: A Multiplying Effect
Ma. Luisa Franco Morales, Laura Navarro, and Maria de Jesús Teniente; Program for the Conservation of Mexican Bats

The Program for the Conservation of Mexican Bats (PCMM) and in coordination with teachers of the Natural Science Academy for the National Teacher's School (BENM) in Mexico City, have designed a course directed at second year of undergraduate students who are studying to be teachers. All of the students from each generation receive a training course intended to teach them about bats, so that they are able to replicate, design, or adapt the information, materials, and activities when they become teachers in the near future. The course shows them the educational programs that the PCMM has designed for the different species: *Tadarida brasiliensis*, *Leptonycteris curasoae*, *Desmodus rotundus*, *Artibeus jamaicensis*, *Noctilio leporinus*, and *Vampyrum spectrum*. Along with the activities and games, we additionally present an exhibit called "Bats, a Myth in our Culture." For proper completion of the course, young teaching students should implement this information and deliver a professional practice to some invited public schools corresponding to the 4th to 6th grade of basic education. These practices have been given the name "Let's Preserve the Bats," where children are taught the information first given teachers, and then actively participate in discovering the importance that bats have on the ecosystem. We first started this collaboration in 2001, and for seven consecutive years we have participated in the formation of future teachers with a complex subject that includes scientific content, educational materials, and methodological strategies within the classroom. We have generated much feedback and a multiplying effect for the subject of bats, which has been introduced into scholar activities, National Educational Forums, thesis work, and implementation of bats in their professional activities—all helping in the conservation of bats.

Education Activities for Bat Conservation in Bolivia

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The mission of the Bolivian Bat Conservation Program (PCMB) is to promote bat conservation in Bolivia and bat ecosystems through research and education to guarantee the maintenance of ecological process that benefits humans and nature. With this base line, the Program started its activities in 1998, and during 1999 a study about Bolivians' perception about bats was conducted in the three main departments of Bolivia (La Paz, Santa Cruz, and Cochabamba). From the results, we planned and conducted different educational and public outreach activities, including workshops, museum exhibits, press releases, and the development of educational materials to support the activities. Public outreach included capacitating teachers, lectures to students, universities, communities, cattle ranchers, among others. To date, we have worked in six of the nine Bolivian departments reaching directly to about 60,000 people and indirectly to more than 150,000. Long-term evaluation of the workshops shows that people are changing their attitudes and perception about bats. After nine years of continuous educational work, we organized a national workshop to highlight the best experiences on education and public outreach. There we designed a manual that will help to continue our educational efforts and to more efficiently reach people. Educational activities are crucial to change people's attitudes about bats, and both are crucial to bat conservation.

New Elements in Fragmented Landscapes: Outstanding in Bat Conservation

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Landscape fragmentation results from intense human activities, causing habitat loss and diminishing biodiversity. The process: split and disconnect the landscape in more and more small fragments, separated by a matrix generally formed with elements alien to the original forest; there is habitat loss (quantity and quality), leading to isolation of natural populations. These changes create new elements—croplands and plantations, edges, corridors, isolated trees, and a matrix—altering patterns and processes leading to local extinctions. But, are these new elements favorable for some bat diversity? Several studies found positive effects on some taxa diversity (birds, rodents, large mammals, insects). Our data in Mexico also showed that some bats take advantages of these new elements. At coffee plantations we captured 901 bats (26 species); bat species are comparable among coffee plantations and forest fragment, but species composition varies across plantations and forest. Coffee plantations with the most developed vegetation structure (greater tree richness and basal area) had greater bat richness and diversity than plantations with the less developed structure, but this pattern may be altered by the landscape around plantation and its management. At three habitat types (interior forest fragments, edges, and matrix -sugar cane), we collected 151 bats (11 species); no differences between habitats' species richness was found, but edges showed the highest abundance (71.5%) and species richness (64%), providing food resources, and could function as dispersal routes in fragmented landscapes. At pastures with isolated trees and riparian corridors in fragmented landscape, we collected 652 bats (20 species); they were more abundant and diverse at riparian corridors. Most common species in all of our studies were frugivorous, habitat generalists highly tolerant to perturbation and heterogeneous landscapes, but they were responsible of regeneration of forest at perturbed and open areas. New elements in the landscape seem to be outstanding in bat conservation.

Edge Effect on Seed Dispersal by Bats at Fragmented Tropical Subdeciduous Forest in Central Veracruz, Mexico

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Rates of tropical deforestation continue to exceed those of forest regeneration, and edge forest (habitat edge) between forest fragments and surrounding matrix are becoming ubiquitous features of tropical fragmented landscapes. Bats are a key biological component of Neotropical ecosystems, and play crucial roles in rainforest dynamics. Frugivorous bats are very important in plant-dynamics and the recovery of forest at Neotropical fragmented landscapes. However, the knowledge about the response of frugivorous bats to habitat edge and its consequences on seed dispersal is lacking. During one year, we monitored frugivorous bats and fecal samples at three netting sites, each one representing three habitat types (forest fragments, edge forest, and matrix) on fragmented landscape. We measured and compared species richness, abundance, and Shannon-Wiener diversity index of frugivorous bats among habitat types, and we also analyzed seeds dispersed by bats using Disperser Importance Index (DII). We captured 143 frugivorous bats (7 species): 23 bats (7 spp.) inside forest fragments, 104 (5 spp.) at edges, and 16 bats (4 spp) at matrix. H' index of bats was 0.6788 at forest, 0.2489 at edges, and 0.4792 at matrix. Only bat abundance was different among habitats (ANOVA, $F = 6.56$; $df = 2$; $p = 0.03$), higher at edges than the matrix ($q = 3.37$; $p = 0.03$). *Sturnira lilium* (69.53%) and *Carollia perspicillata* (14.56%) were the most abundant species at all habitats; *S. lilium* was the most abundant at edges (82.40%). We obtain 85 fecal samples (8,364 seeds) (13 species) in 5 families: *Piperaceae* (90%), *Solanaceae* (4%), *Cecropiaceae* (4%), *Moraceae* (1%), and others (1%). *S. lilium* was the most important disperser on the landscape, also at edges (DII = 7.18) and at the matrix (DII = 3.27), but *C. perspicillata* was the most important disperser inside forest (DII = 2.79). Habitat edge functions as 1) foraging habitat for some frugivorous bats, and 2) a source of seeds for dispersal and recruitment in fragmented landscapes.

Fruit-eating Bats in a City: The Case of San Jose, Costa Rica

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Urban areas represent the peak of anthropogenic impact on the environment, since humans remove most of ecological resources necessary for the survival of wildlife fauna in these areas. Given the degree of habitat alteration in cities, urban parks provide an important refuge for different types of organisms. From September 2005 to January 2006, I captured bats with mist nets in six parks of downtown San Jose. I analyzed diet, abundance, and species richness in each park in relation to park area, tree abundance, and food resources. I found five bat species in these parks: *Artibeus jamaicensis*, *A. lituratus*, *Glossophaga commissarisi*, *G. soricina*, and *Sturnira lilium*. Additionally, I found a positive relationship between bat abundance and food resources. Therefore, park area is not relevant for bat abundance; it is the species composition of each park's flora that determines bat diversity and abundance. This information provides a base line for decision-making in regards to urban landscape design, wildlife conservation, and management of urban environments.

Techniques for Maintenance of the Curaçaoan Long-nosed Bat, *Leptonycteris curasoae* (Phyllostomidae, Glossophaginae), in Captivity

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General techniques described in the literature for maintenance of nectar-feeding bats in captivity are not satisfactory to fulfill the particular requirements of all species. To study the behavior of an experimental colony of 18 specimens of *Leptonycteris curasoae* during 10 months, we designed captivity conditions to guarantee the optimal maintenance of the group. Bats were maintained in a 5 x 2.5 x 3 m room, with areas separated for feeding and roosting. Temperature and humidity were kept close to natural conditions (26–30ºC and 70–100%, respectively). Photoperiod was maintained naturally. Based on the nectarivorous and pollinivorous habits of the species and its close association with xeric environments, we offered five food types *ad libitum*: fructose + sucrose solution (28% m/v), fructose + sucrose solution (18% m/v) + ENTEREX® (3.3% m/v), fruit jam with pollen, ground pollen, and cactus fruit pulp and/or bananas. We recorded the volumes of each food type consumed daily and determined feeding preferences. Weight, hair health, presence of ectoparasites, and reaction capacity were evaluated on each individual every week during the first six months, and every two weeks after the seventh month. The sugar solution, sugar solution + ENTEREX®, and pollen were the preferred food items. There were 1–7 g fluctuations in body weight during the 10-month period. Only two individuals suffered recurrent weight loss and died. Animals were active during the day and we did not observe hair loss or wounds in the specimens. Under these conditions, maintaining small colonies of *L. curasoae* in captivity for long-term behavioral studies is possible.

Demography of *Dermanura tolteca* (Phyllostomidae) in Sierra Norte, Oaxaca, México
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The Toltec Fruit-eating Bat *(Dermanura tolteca*, Phyllostomidae) has a wide distribution in the Neotropical region, and can be a predominant element in those communities in which it is present. However, in spite of this, studies of demography characteristics have not been published to date. Our objective is to determine population size, sex ratio, age structure, and reproductive pattern of one population of the Toltec Fruit-eating Bat in a tropical forest of Sierra Norte de Oaxaca, a very biodiverse region. We captured, marked, released, and recaptured *D. tolteca* in San Martín Soyolapan, Municipio Santiago Comaltepec, from May 2006 to April 2007. A total of 167 bats were caught with mist nets, and marked by mean of numbered fasten-cable. Total sampling effort was of 22,080 m of net per hour. Proportion of sexes was male biased (1:1.3), but the difference was not significant (p = 0.062). The adults represented 73% of the captures, follow by subadults (24%), and then juveniles (3%). Reproduction was from July to October. Population size was estimated with closed-populations models, building in the MARK software. From the several candidate models, the best model was selected by the Akaike's Information Criterion, and the estimation of population size was made by means of the program CAPTURE. Our best model was with time variation (*Mt)*; the estimated population size was 3,375 individuals with monthly fluctuations from 1,106 to 0.

Bats from San Juan de Camarones, Durango, México
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San Juan de Camarones is located in southwestern Durango State, México. It is considered a conservation hot spot (RTP-23, CONABIO) due to the integrity and complexity of the ecosystems found there. It is also a transition zone between the pine-oak areas of the Sierra Madre Occidental and the tropical vegetation of the Pacific Coastal Plain. Nearctic and Neotropical species, that possibly are using the canyons (barrancas) as corridors, can be found in the Sierra. The objective of this work is to show the high bat diversity in the area and compare it with other areas in México. So far we have recorded 31 bat species, and 15 more with potential distribution in the area. The presence of seven species of the family Molossidae in a single locality was previously reported for this area, being the only one with such high diversity of molossids in Mexico and North America. Forty-six species are reported for San Juan de Camarones; this is twice the number reported from the Baja Tarahumara Sierra region, Chihuahua (23 spp.), and only four species less than the total number reported from Chajul station, UNAM, Chiapas (50 spp.), which is one of the zones with the highest bat diversity in México. These results indicate the need to continue work in the canyon areas, and support that the zone should be considered a protected area for biological diversity.

Alpha and Beta Diversity of Bats within a Natural Protected Area in the State of Tabasco, Mexico

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The study of diversity within landscapes has recently been an important subject due to the accelerated transformation of the natural ecosystems, which bring about the loss of biodiversity. The object of this study is to determine the Alpha and Beta diversity of bats within the La Sierra Reserve in Tabasco, Mexico. This Reserve is formed by three Sierras (Mountain ranges)—Poana, Tapijulapa, and Madrigal—each with a different degree of conservation. Three sampling sites were established for each Sierra, and in each, two types of vegetation were sampled using three nets of 12 mts. The species richness and the Shannon-Weiner index were estimated for the Alpha diversity; the potential number was obtained using Jacknife of the 1st order. The Beta diversity between sierras and vegetation was obtained with the Chao-Jacard-Sorensen Index. Thirty-three species of bats were registered for the Reserve. Poana, Madrigal, and Tapijulapa registered 18, 21, and 30 species, respectively. The expected number of species was 18, 23, and 34, correspondingly. For each vegetation type, 22 species were registered in acahual and 32 in rainforest. The acahual with the highest diversity was in Poana (2.875), while the rainforest of Tapijulapa was the most diverse (3.346). The strongest similitude between Sierras was between Tapijulapa and Madrigal (1), taking into account the vegetation type; the acahual of Madrigal and Tapijulapa were the most similar (0.981); and for the rainforests Madrigal and Poana proved the most similar (0.994). The Poana Sierra is the most fragmented and deforested; most of the species present are generalists. The Tapijulapa Sierra presents a higher degree of conservation and registered a higher number of specialist species. The habitat disturbance of the Sierras affects the composition of the bat communities present in them.

Reliability of Habitat Selection Evaluation by the Euclidean Distance Method in Different Landscape Configurations

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A diverse array of analytical approaches is available to study habitat selection. Although they work under different underlying hypotheses, researchers often use them indistinctly, mostly with the aim to compare the preferences of animals between different vegetation classes. Recently, a new approach based on Euclidean distances has been proposed as a tool to analyze the spatial features determining the distribution of animals, and it has drawn some interest from bat researchers. Unlike classification-based approaches (CBA), it is less prone to bias when locations of animals in habitat categories are miss-classed or certain triangulation error exists. Nevertheless, landscape metrics may affect the analysis of preferences for habitat categories in the distance-based approach (DBA) because it depends strongly on a spatial variable such as the Euclidean distance. We simulated two landscapes with different levels of association between four habitat categories where points were placed simulating animal locations with two contrasting selection patterns. In addition, telemetry error was simulated in each of the landscape-location pairs. The DBA was not able to produce a reliable ranking of preference where the landscape showed association between patches of some habitat categories. Simulated telemetry error did not change the preference pattern that arose when exact locations were used.

As a case study we compared the results obtained by the DBA and a CBA when analyzing the habitat selection of medium-sized horseshoe bats in Southern Spain. In general habitat patches were large, so that the degree of mosaicism was low, and foraging bats were located mostly in only two habitats, which appeared separately in the landscape. No approach was able to highlight a rank of preference for the habitat categories, although the reasons were different. CBA suffered from extreme sensitivity to unused categories, and the high degree of association between some categories likely affected the results of DBA.

Dietary Partitioning by French Guiana's Nectarivorous Bats: Preliminary Data

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Neotropical nectar-feeding bats (Phyllostomidae; Glossophaginae) have been hypothesized to feed in a fine-grained fashion, or more simply, each glossophagine species is likely to feed at most kinds of bat flowers in its community. The pristine lowland moist forest at the Nouragues field station is home to four of French Guiana's seven species of nectar-feeding bats (*Anoura geoffroyi, Choeroniscus minor, Lionycteris spurrelli, Lonchophylla thomasi*), which makes it an ideal location for testing this hypothesis. Two species (*A. geoffroyi*, *L. spurrelli*) dominate bat captures there and should theoretically utilize similar floral resources. However, preliminary results from fieldwork conducted in November–December 2006 and March–April 2007 indicate that this is not the case. Pollen of *Eperua falcata* (Fabaceae) dominated the samples collected from fur and feces of *A. geoffroyi* and *L. spurrelli* in the dry season (late November and December). Even the larger phyllostomine (*Phyllostomus latifolius*) appeared to have visited these flowers. However, in the wet season (March–April) when floral resources are believed to be more limited, pollen from *Lecythis poiteaui* (Lecythidaceae) was found in the feces of *A. geoffroyi* and *L. thomasi* and that of *Psittacanthus acinarius* (Loranthaceae) in the fur and feces of *A. geoffroyi*. During this time, no pollen was detected in samples obtained from *L. spurrelli*. Further collections in other times of the year will help shed light on these differences. In addition to these findings, the identification of *P. acinarius* in the diet of *A. geoffroyi* marks the first account of bat pollination in the Loranthaceae plant family and in the entire Santalales order in the New World. The discovery of a chiropterophilous species among these hummingbird-pollinated mistletoes highlights the importance of considering all flowering plants, not just ones that fall into the bat-flower syndrome, as possible food sources when attempting to identify the bats' dietary components.

Adding up the Neotropics' Bat/Plant Interactions

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Accounts of pollination and seed dispersal by bats in the New World date back to as early as 1897 when Hart noted bats visiting flowers of *Bauhinia megalandra* and *Eperua falcata* in Trinidad. Since that time there have been hundreds of published observations and experimental studies focusing on bat/plant interactions in the Neotropics. Keeping track of this ever-expanding body of knowledge has previously taken the form of compilations starting with van der Pijl's 1957 work, which identified 47 bat-dispersed species from 27 Neotropical plant families. Twenty years later in 1977, Gardner listed 103 plant species in the diet of phyllostomid bats. Today, thanks to microcomputers and the Internet, compilations of this sort can be continually updated and accessible to practically anyone anywhere in the world. We have constructed an Access database for compiling all published bat/plant pollination and dispersal interactions. For each interaction we include the plant family, genus, and species, bat genus and species, pollination (yes or no), dispersal (yes or no), and reference (authors and year). These data are available and periodically updated at a Web site entitled *Bat/Plant Interactions in the Neotropics* (http://www.nybg.org/botany/tlobova/mori/batsplants/introduction/intro_frameset.htm). Such information can be used in various ways, both from zoological and botanical perspectives. For instance, the database can produce a list of all known food plants in the diet of the wide-ranging bat *Carollia perspicillata*. In addition, it can be used to compare the resources available to frugivorous bats at different locations, such as those on Barro Colorado Island and Central French Guiana. It also can be the first stop when examining the convergent evolution of bat pollination in the many plant families in which it has arisen. All of these examples will be discussed as well as the many caveats to using data compiled from many disparate sources.

Ranging Accuracy For Sinusoidally Jittering Real Targets in a Free-flying FM Bat

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The auditory system measures time with amazing precision. Echolocating bats use the time delay between call and echo for ranging, i.e., to measure the distance to objects in their environment. Simmons and colleagues introduced jitter experiments with virtual targets to measure ranging accuracy. Their bats discriminated jittering echoes (with alternating echo-delay between calls) from stationary echoes (with a constant echo-delay) down to a threshold of 10 ns of temporal jitter. Here, we tried to simulate a semi-natural situation by using free-flying bats and simple real targets to investigate ranging accuracy under more natural conditions. We used two objects (bass loudspeakers) as targets, one of which was slowly vibrating (10 or 25 Hz) and thus changing its distance to the bat. In a rewarded two-alternative forced-choice paradigm, we trained free-flying flower-visiting bats (*Glossophaga soricina*) to select the vibrating object and measured a psychometric jitter-detection function by reducing the vibration amplitude, i.e., the speaker displacement. The discrimination threshold was at a peak-to-peak displacement of 10 and 5 mm for vibration frequencies of 10 and 25 Hz, respectively, corresponding to 60 and 30 μs peak-to-peak echo-delay. However, the peak-to-peak echo-delay rarely corresponds to the perceived echo-delay, since the bat only measures the distance when it emits a call. The estimated perceived temporal jitter between successive call-echo-pairs, based on a typical inter-call-interval of 18 ms, is for both vibration frequencies at most around 30 μsec (5 mm) and on average around 18–20 μsec (3.0–3.4 mm). Frequency cues caused by Doppler shift were below frequency resolution and thus cannot explain the results. A ranging accuracy of around 3–5 mm seems to be sufficient for orientation in front of bat-pollinated flowers, which are the relevant objects during foraging and which presumably exerted the highest evolutionary pressure on ranging accuracy in *G. soricina*.

Characterization of Natural Breeding Roosts of Bechstein's Bat (*Myotis bechsteinii*) in Central Iberian Peninsula: More Oaks and Woodpeckers, Please!

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Within broader research about the Bechstein's bat in Extremadura (central Iberian Peninsula) in Spain, one of our aims was to characterize the natural roosts used by the species. Information about roosts found in literature largely referred to artificial roosts, and amazingly little has been published about the natural roosts of this European species, although it has been pointed that old trees might be important. We captured 53 Bechstein's bats at water points using mist nets, and radio transmitters (0.35 g) were attached to 28 females showing signs of lactation. By tracking the bats we found 13 roosts, all home to breeding colonies. All of the colonies were located in sessile oaks (*Quercus pyrenaica*), a sub-Mediterranean small oak species that rarely exceeds 20 m in height. Average colony size was 20 bats (standard deviation = 10.7). Other parameters used to characterize the roosts showed high variability: height of roosting tree (mean = 11.8 m, sd = 2.77), height of roost entrance (mean = 4.9 m, sd = 2.02), roosting tree diameter at breast height (mean = 41 cm, sd = 17.6), percentage of dead branches (mean = 24, sd = 26.1), orientation (mean = 183º to the magnetic north, sd = 124.0). Among the 13 holes, 10 were former woodpecker holes and 7 had been modified by the nuthatch (*Sitta europaea*), thus showing a narrower entrance lined with mud (less than 4 cm in diameter). In conclusion, the combination of certain tree species (at least some oak species) and the existence of woodpeckers are good predictors of the presence of Bechstein's bat in the Iberian Peninsula. However, the high variability of the studied physical features of the home trees precludes their use as diagnostic variables to identify suitable roosts. Additionally, historical reasons, availability of prey and water sources, or frequency of annual rainfall may play important roles in order to understand the distribution of this rare bat.

Karyotypic Study of *Diphylla ecaudata* (Desmodontinae) with Five *Carollia brevicauda* (Carolliinae) Whole Chromosome Probes

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Great effort has been made concerning Phyllostomidae karyotypic evolution elucidation through comparisons between species of G-banding patterns. However, in some circumstances these data might not provide the true evolutionary history of chromosome segments due to similarity of non-homologous bands. Recent studies have overcome this situation by applying chromosome painting to reveal syntenic segments between species. In this study we hybridized five whole chromosome probes of *Carollia brevicauda* (2n = 21, XX/XY_1Y_2) in *Diphylla ecaudata* mitotic metaphases (2n = 32, XX/XY) and performed G-banding analysis in order to identify conserved segments between both karyotypes. The probes used (CBR 3, 5, 7, 8, and 9) were developed in the Molecular Cytogenetics Lab., University of Cambridge, UK. The specimens were captured in Toritama, Pernambuco State, Brazil. The hybridization data revealed six conserved segments between the two species. Four paints of *Carollia* were hybridized to whole chromosomes of *Diphylla* (CBR 3, 5, 7, and 9) and two of those five paints hybridized in the whole chromosomal arms of *Diphylla* (CBR 3 and 8). Zoo-FISH plus G-banding data allowed the identification of homeologies between *Diphylla ecaudata* and other Phyllostomidae species whose chromosome painting was previously reported. For instance, CBR 9 corresponded to chromosome pair 14 in *Phyllostomus hastatus*, *Glossophaga soricina*, and *Diphylla ecaudata*. A further step in this analysis uses the remainder of probes of *Carollia brevicauda* and *Phyllostomus hastatus* in all Desmodontinae species karyotypes to determine their genome-wide homologies and use them as the outgroup to other Phyllostomidae species, once Desmodontinae is considered one of the most basal groups in the family.

Cranial Morphometrics and Cytotaxonomy of the Large-sized *Artibeus* (Leach, 1821) from Pernambuco State (Northeastern Brazil)
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Although several studies have been performed, systematics and taxonomy of fruit-eating bats from the genus *Artibeus* are still controversial. Four species of large-sized *Artibeus* are registered for Brazil: *A. obscurus*, *A. jamaicensis*, *A. lituratus*, and *A. fimbriatus*. These species are difficult to distinguish, particularly in the Northeastern region, where a higher overlapping of measures is found between *A. jamaicensis* and *A. obscurus* and between *A. lituratus* and A. *fimbriatus*. In Pernambuco State lack of information concerning morphometrics and distribution is still considerable. In the present study, we used nine cranial measurements plus cytogenetic data analysis to distinguish these four large-sized *Artibeus* species. Cranial measurements revealed differences between all of them. *A. lituratus* is larger than the other three species studied, followed by *A. fimbriatus*, *A. jamaicensis*, and *A. obscurus*. The existence of two groups has been verified: one composed of lesser species, represented by *A. jamaicensis* and *A. obscurus*, and another group represented by larger species, consisting of *A. lituratus* and *A. fimbriatus*. The only exception to this pattern was obtained for post-orbital constriction width measures, in which *A. lituratus* and *A. obscurus* appeared to be more similar, as well as *A. jamaicensis* and *A. fimbriatus*. The karyotypes of all four species consist of diploid number 2n = 30/31, XX/XY_1Y_2 and fundamental number (FN) = 56. C-banding data have revealed CH blocks in the pericentromeric region of all autosomes and at the telomeric region of pairs 5, 6, and 7. An additional interstitial block is found in the long arm of pair 6 except for *A. fimbriatus*. The distinction of the remnant species is made due to the presence of additional telomeric and interstitial CH blocks in *A. jamaicensis* and *A. obscurus*. All of the data will contribute to the establishment of a pattern in species identification to the Brazilian Northeastern region.

Population Fluctuations of *Tadarida brasiliensis mexicana* in Northeast and South México
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Tadarida brasiliensis mexicana migrates from the center and southwest of the U.S. to central and southern México in winter because it probably is correlated with the patterns of emergence, migration, and availability of noctuid moths (essential diet component). Later the females return to the north caves to breed in the summer. The lack of information about seasonal movements along the migratory routes in México prompted this study. The objective was to document population fluctuations in three representative caves in northeast, central east, and southeast México: “La Boca”, Santiago, Nuevo León, “El Salitre”, Metztitlán, Hidalgo and “San Francisco”, La Trinitaria, Chiapas. The data consist of bimonthly censuses from May 2005 to December 2006 in each cave using a video camera to film the colony during evening emergency and to record the time for laboratory analysis at a later time. The results indicate that the central and south populations are present year-around, and in the north cave they are absent from December to April. Population magnitudes are very different (La Boca 4,000 to 2 million, El Salitre from a few hundreds to 110,000, and San Francisco from one thousand to 650,000) and fluctuate seasonally, being more abundant in the wet season (June 2006 and June 2005) and scarce in middle of the dry season (March 2006). These numbers are contrary to reports in the literature, although there are no precise demographic or movement studies with this species in the country. La Boca population follows the typical migratory pattern of south Texas.

Variation in Bat Activity Patterns at Cattle Ponds in La Michilía Biosphere Reserve, Durango, México

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La Michilía is a protected area of the MAB-UNESCO reserve system located on the southern portion of Durango State, México, on the highlands of the Sierra Madre Occidental. Elevation ranges from 1900–2800 m, climate is temperate, with well-marked dry, rain, and winter seasons. Fifteen species of bats are known from Michilía, 14 vespertilionids and 1 phyllostomid. Understanding the relationship between environmental factors and bat activity can provide insights into the ecological requirements of the local assemblage. Using heterodyne echolocation signals and mist nets we described activity patterns of insectivorous bats in seven cattle ponds within the reserve. Also we related bat activity with a set of environmental variables (temperature, relative humidity, moon phase, pond area, and rain-dry seasons). Activity decreased significantly below 10°C, and was significantly higher during the dry season. We also found a significant positive correlation between moon phase and bat activity during the dry season. Relative humidity and pond size had no significant effect. A strong correlation between number of echolocation pulses and feeding sequences (buzz) was found in both seasons, but was slightly higher during the dry one, which suggests that ponds are being used as foraging and drinking sites. Mist-net data suggest that the bat assemblages using these ponds differ between seasons. During the rain season mostly water-surface foragers were caught, whereas the dry season forest/clearing aerial and open-air foragers were the most frequent captures. Results suggest that these ponds become important for a wider number of species during the dry season.

Alimentary Resources Found in the Diet of Colombian Frugivorous Bats

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Little details are known regarding to dietary habits of Colombian Chiropterans. This study presents a list of species of plants consumed by some significant species of frugivorous bats in Colombia. The aim is to provide additional evidence towards the enrichment of scientific discussion over one of the dimensions of the niche: the alimentary resource, taking into account that competence for it and mutualist relationships have been considered as key factors in the structure of the ensembles of bats. The methodology applied consisted in the analyses of feces and stomach contents of specimens found in different regions of Colombia: Amazonian, Andean, Caribbean, and Orinoquia, which represent varied types of habitats. The bat specimens were collected between 1996 and 2007, and were stored in the Institute of Natural Sciences' Collection of Mammals. Thirteen bat genera were studied, the most representative being *Artibeus, Carollia, Chiroderma, Phyllostomus, Rhinophylla,* and *Sturnira.* The species of plants found as consumed by these bats belong to the following families: Caesalpinaceae, Caprifolaceae, Cecropiaceae: *Cecropia*, Fabaceae: *Batesia,* Geraniaceae: *Geranium,* Leguminosae: *Bauhinia,* Melastomataceae, Mimosaceae, Moraceae: *Ficus,* Myrtaceae, Passifloraceae, Piperaceae: *Piper,* Rutaceae: *Zanthoxylum*, and Solanaceae: *Solanum*. New food items are reported are *Batesia* (Fabaceae) for *Artibeus obscurus* in preserved forests, and *Zanthoxylum (Rutaceae)* for *Carollia perspicillata* in disturbed forest. Presence of the *Rhinophylla fischerae* and *Sturnira lilium* in secondary, relatively preserved forests is highlighted. The results suggest the need to promote new specific research on the types of ecological interactions between the plants found and the different species of bats that consume them, in order to define the role performed by these flying mammals, and to develop guidelines for conservation and better use and management of the agro ecosystems and the ecosystems in the tropical forest.

The Bat Research Group in Uruguay: Actions and Challenges
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Twenty-two species of bats have been recorded in Uruguay until now. Nineteen of these are insectivorous, two are frugivorous, and one is hematophagous. The ecological role and the conservation status of these mammals are mainly unknown in this country. Nevertheless, several human activities have been identified as potential threats for bats and three of these are considered as particularly damaging: 1) the action of companies of plagues exterminators, basically in urban environments; 2) the loss and degradation of habitat and refuges in rural environments; and 3) the lack of information and public awareness related to the importance of bats. The GIM (Bat Research Group) was created in 2004 with the aim of analyzing and finding solutions for these problems. Since that time, the GIM has contacted the governmental office related to the fauna and the Association of Plagues Exterminators and several actions were settled on to diminish the impact of their activity in urban colonies of bats. An inedit report on the conservation of bats in Uruguay has been prepared, including an analysis of conservation pressures and management recommendations. Recently, the GIM has started an educational program at the national level. As challenges, the group faces the lack of sensibility at social and political levels related to our topic, and the scarcity of human, material, and economic resources for the work.

Nectar Extraction Capabilities of the Specialized Nectarivorous Bat *Musonycteris harrisoni*
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The Colima long-nosed bat *Musonycteris harrisoni* (Phyllostomidae: Glossophaginae) is morphologically one of the most derived nectar-feeding bats in the Neotropics. It shows an enormously elongated long rostrum that has been suspected to permit the species to specialize on the nectar from long-tubed bat flowers. In flight cage experiments, we studied the nectar extraction capabilities of *M. harrisoni* from test tubes with variable nectar-levels and compared them to those of the sympatric flower-visiting bats species (*Leptonycteris curasoae, Glossophaga soricina, Anoura geoffroyi, Choeronycteris mexicana*) at our study site in Colima, W-Mexico. Preliminary results show that lower nectar levels resulted in a decreasing amount of nectar extracted per visit as well as longer hovering durations for all species, indicating a higher energy investment necessary when foraging on long-tubed flowers. In the field, the only long-tubed (approx. 70 mm) flowers used by *M. harrisoni* were those of the columnar cactus *Pachycereus pectin-aboriginum,* although these are available only for part of the year. The long rostrum and long tongue probably enables the small *M. harrisoni* to use the entire set of bat flowers available in an area, which allows the specialization on a pure nectar diet over the annual cycle without the necessity to switch to other food types or to migrate. Also, the range of the long tongue allows *M. harrisoni* an approximately 10–20 mm deeper access into the cactus-flowers, which might allow collecting even the last available nectar rests that are not accessible to the more abundant, coexisting species.

Diversity, Community Structure and Roost-site Selection of Bats in a Deciduous Seasonal Forest in Veracruz, Mexico
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The endangered Mexican long-nosed bat (*Leptonycteris yerbabuenae*) is a relatively common species of deciduous seasonal forests across southeastern México. However, relatively little quantitative data are available describing the effect that roost-site selection of this species has on bat community structure in general, and specifically in a deciduous seasonal forest in Veracruz, Mexico. Understanding roost-site selection of this species is critical for its conservation. As part of a long-term study on bat ecology and conservation in deciduous seasonal forests of Veracruz, we collected and integrated information about bat diversity, bat community structure, physical parameters of three caves, and the roost-site selection of bats living inside of these caves. The objectives of this analysis are: 1) to identify the richness and diversity of bat species living in a deciduous seasonal forest in Veracruz; 2) to describe the spatial-temporal use of caves of *Leptonycteris yerbabuenae*; 3) to evaluate the effect on the bat community in general due to the presence/absence of *Leptonycteris yerbabuenae*; 4) to research fluctuations in the population of *Leptonycteris yerbabuenae*; and 5) to research the impact of guano from other bat species on the nesting sites and reproductive patterns of *Leptonycteris yerbabuenae*. Field data demonstrated that two of the three caves we studied were inhabited by *L. yerbabuenae*, although the spatial–temporal use of the caves varied in accordance with species richness, bat community structure, and complexity of the caves. Indirect evidence showed that guano recollection for use as fertilizer has both positive and negative effects on bat community dynamics.

Seasonal Bat Diversity in Three Habitats to the Western of Cañon del Sumidero, Chiapas
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Bats are an important group of mammals and play key roles in the natural ecosystems and fragmented habitats principally as pollinators and seed dispersers, promoting plant recolonization in these areas. During January to December of 2006 we sampled bat communities at the Cañón del Sumidero National Park to Northwestern of Chiapas, México at shaded coffee, pastureland, and no wooded cultivation (corn/banana). Bats were captured using four mist nets at each habitat twice during dry and rainy season. We compared species richness, abundance, and diversity (alpha-beta) of bats between habitats and seasons. The greater species richness was found in pastureland (11) followed by no wooded cultivation (10) and shaded coffee (7); however we found no differences between seasons at each habitat. *Sturnira lilium*, *Artibeus jamaicensis*, *Dermanura tolteca*, and *Carollia sowelli* accounted for 75% of all bats captures. Bats were most abundant in dry and rainy season for the pastureland (x^2 = 71.59, g.l. 10) and shaded coffee (x^2 = 21.83, g.l. 6) respectively. With respect to alpha bat diversity (Shannon) we found no differences (t = 1.586, g.l. $p < 0.05$) between no wooded cultivation (H' = 2.016) and pastureland (H'= 1.838), but whether with shaded coffee (H'= 1.59). We found differences between seasons for the shaded coffee (t = 1.89, g.l. 379, $p < 0.05$) and pastureland (t = 1.89, g.l. 165, $p < 0.05$); both had most diversity in the dry season (H'= 1.543 and H' =1.805, respectively). Sorensen's index of similarity was 0.452 between shaded coffee and no wooded cultivation, followed by pastureland and no wooded cultivation (0.242). Shaded coffee and pastureland had lower values (0.215). Bats help to reestablish the vegetation natural within the fragmented habitats and maintain a balance on the ecosystems. Only understanding the processes that affect the dynamics of these animals we might propose alternatives for their conservation and protection.

Assessing Bat Detectability and Occupancy with Multiple Automated Echolocation Detectors
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Occupancy analysis and its ability to account for differential detection probabilities is important for studies in which detecting echolocation calls is used as a measure of bat occurrence and activity. We examined the feasibility of remotely acquiring bat encounter histories to estimate detection probability and occupancy. We used echolocation detectors coupled to digital recorders operating at a series of proximate sites on consecutive nights in two trial surveys for the Hawaiian hoary bat (*Lasiurus cinereus semotus*). Our results confirm that the technique is readily amenable for use in occupancy analysis. We also conducted a simulation exercise to assess the effects of sampling effort on parameter estimation. The results indicate that the precision and bias of parameter estimation were often more influenced by the number of sites sampled than number of visits. Acceptable accuracy often was not attained until at least 15 sites or 15 visits were used to estimate detection probability and occupancy. The method has

significant potential for use in monitoring bat activity trends and in comparative studies of habitat use.

Bat Cell Culture, a New Tool for Virology or the Connection Between Lab Work and Field Observations

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Although research in virology was confronted with new paradigms of emergence, virology techniques evolved dramatically in last past decades, while cell culture remained a basic and indispensable part of virus isolation, characterization, and description. From cell biology point-of-view, the diversity of commonly used cell cultures appears great, but is quite poor in terms of species representation compared to life diversity. Moreover, the preponderant and re-discovered roles of bats in several emerging diseases, which cause important outbreaks such as the recent SARS-CoV pandemic, make the development of adapted cell lineages to handle and study these viruses essential. Here we present the pertinence, potential, and limitations of bat tissue primary culture techniques that are suitable for bat-borne virus isolation. The aim is to obtain testable and easily grown bat cell cultures that are suitable for freeze-banking and that can be used in virology for research and diagnostic testing.

Vampire Bat Breath Reveals Dietary Preference for Cattle

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Although vampire bats (*Desmodus rotundus*) can have an impact on livestock farming and public health, information on dietary preferences of free-ranging vampires is scarce. We used the stable carbon isotope ratio of exhaled CO_2 ($\sigma^{13}C_{breath}$) to assess whether vampires of a Costa Rican population were members of a C_4 food web (grass and livestock) or a C_3 food web in which vampire bats were caught (a rainforest remnant and its mammals). For an improved understanding of factors influencing the $\sigma^{13}C_{breath}$ of free-ranging vampires, we conducted feeding experiments with captive vampire bats. The mean $\sigma^{13}C_{breath}$ of starved bats was depleted in ^{13}C in relation to the previous diet by ca. 5‰. Once fed with blood, $\sigma^{13}C_{breath}$ levels off within a short time above the stable carbon isotope signature of the diet, i.e., $\sigma^{13}C_{breath}$ became enriched in ^{13}C in relation to the diet by ca. 2‰. The median time required to exchange 50% of the carbon atoms in exhaled CO_2 with carbon atoms from the recently ingested blood equalled approximately 20 minutes. The median $\sigma^{13}C_{breath}$ of starved free-ranging vampire bats equalled -18.8‰. Given that $\sigma^{13}C$ of livestock equalled ca. -13‰ and that $\sigma^{13}C_{breath}$ of starved vampires was depleted in ^{13}C in relation to the last diet, we conclude that the vampire bats of our study site foraged almost exclusively on cattle, although rainforest mammals such as peccaries were present. This is supported by the $\sigma^{13}C$ in wing tissue and fur of the same individuals. Since $\sigma^{13}C$ of wing tissue and fur integrates over weeks and months and $\sigma^{13}C_{breath}$ over hours, we summarize that vampires consistently chose cattle as their prey during and prior to our study period.

Costs and Benefits of Avoiding Torpor: Does Evaporative Water Loss Influence Physiological and Ecological Responses in Ground-Roosting Bats?

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The ability and proclivity of bats and other small animals to use torpor to conserve energy is well documented. In addition to saving energy, torpor also conserves body water that would otherwise be lost through evaporation. During pregnancy and lactation, however, deep or prolonged torpor is viewed as detrimental because it delays growth and development of young, and may therefore lead to reduced fitness. One potential consequence of avoiding torpor and maintaining high body temperature (T_b) is increased evaporative water loss (EWL). The ability to maintain positive water balance may be important for bats living in warm arid environments, especially for lactating females that export water in milk. I investigated relationships between EWL, metabolic rate (MR), and roost choice in the long-eared bat (*Myotis evotis*), a small insectivorous species that roosts solitarily across much of its range. I measured MR and EWL for *M. evotis* captured in mist nets during the summers of 2005 and 2006, and radio-tracked individuals to day-roosts in mudstone cavities during the summers of 2004–2006. As expected, EWL increased with MR, and reproductive females generally maintained higher T_b and MR than non-reproductive females and males. Patterns of roost selection in free-living *M. evotis* followed familiar patterns; reproductive females chose warm roosts and maintained higher mean T_b during day-roosting periods. Estimates of EWL during roosting periods compared across sex and reproductive categories confront the hypothesis that physiological constraints influence roost selection. Specifically, I hypothesize that reproductive females lose more water per day than non-reproductive counterparts or males and that they select roosts that optimize water conservation while minimizing energy expenditure. I suggest that reproductive females use bouts of shallow torpor to help conserve water as well as energy.

Geographic Variation in Cranial Morphology of *Dermanura phaeotis* (Chiroptera: Phyllostomidae)

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Studies of geographic variation can provide insights into the discovery of historical entities, and despite some attention to the subspecific taxonomy in recent years, geographic variation in *Dermanura phaeotis* has not been assessed since more than 30 years ago. This study represents the first modern attempt to analyze geographic variation and to evaluate the taxonomy of *D. phaeotis*. I examined 16 cranial characters in 434 specimens representing all subspecies. Using univariate and multivariate analyses, I evaluated patterns of morphological disparity and differentiation within and among the putative subspecies. All analyses found no evidence of any groupings in a geographically consistent manner. Analyses of variance and discriminant analysis indicate that, although there is a considerable geographic variation in *D. phaeotis*, it is not possible to consistently refer specimens to particular subspecies and that the currently recognized subspecies artificially compartmentalize the variation in this species. Consequently, these results do not suggest that any application of subspecific taxa can consistently reflect geographic variation in this species; therefore, *D. phaeotis* should simply be considered as a geographically variable species.

Phylogeographic Patterns of *Pteronotus davyi fulvus* from México Inferred from the Mitochondrial Control Region

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The distribution of *Pteronotus davyi fulvus* in Mexico goes from the Pacific Rim to the Gulf of Mexico, throughout the Tehuantepec. The present study determines the phylogeographic patterns of 18 populations of *P. d. fulvus* from México, including the Pacific, the Gulf of México, and the South-East. Five hundred and fifty-five base pairs of the mitochondrial control region were analyzed from 105 organisms. Data were analyzed at the regional and at the population level. At the regional level, sequencing data were analyzed utilizing phylogenetic, haplotype network and Mantel test. At the population level, estimates of genetic diversity (h, π) were determined and the sequencing data were submitted to AMOVA and nested clade analysis (NCA). The resulting phylogenetic relationships, haplotype networks, and mantel test results were congruent and indicated a regional segregation: a Pacific-Gulf group and a South-East group (Nm = 0.86), suggesting gene flow between the Pacific and Gulf groups (Nm = 2.96). At the population level, the AMOVA results also support such hypothesis: 32.7% of the variation ($F_{ST} = 0.43$, $p < 0.05$) was detected between the Pacific-Gulf vs. South-East; and 12.5% of the variation ($F_{ST} = 0.23$, $p < 0.05$) between the Pacific vs. Gulf. The NCA suggests that clades 3-4 and 4-3 are defined by long distance colonization events following fragmentation and restricted gene flow, suggesting the scenario of genetic isolation. The AMOVA results, genetic diversity values, and the absence of shared haplotypes suggest the possibility of an ancient barrier at the Tehuantepec Isthmus. The high diversity values (π) observed at populations Arroyo del Bellaco (0.0191) and Catemaco (0.0194) suggest the possibility of Pleistocene refuges. Furthermore, general low diversity values, supported by F_{ST} and mismatch distribution, suggest dispersion events. The complexity of historical events in the distribution of *P. davyi* in Mexico allows us to suggest the presence of different genetic units of the species within the country.

Adaptive Plasticity and Constraint in the Evolution of Echolocation

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Echolocation systems may seem very plastic when we focus on the most studied vespertilionid bats. However, the variation of vespertilionid sonar systems recurs on the common theme of downward frequency modulated signals, and it can be understood as an sliding along an adaptive continuum from aerial insectivory in open areas, based on long narrowband signals, to substrate insectivory, based on short broadband signals. Other bats may show more variation and less plasticity in the evolution of signal structure. For example, bats in the small family of the Mormoopidae have diversified in a surprising variety of ecological niches within aerial insectivory. Different species forage in radical different ways, and correspondingly use echolocation signals with different structure. When tracing the characters of the echolocation system on their phylogeny, we found that some characteristics of the signals (such as the presence of constant frequency elements) have persisted through important changes in the foraging ecology and the function of the echolocation system (such as loss of narrow frequency analysis), and may have been adapted for other functions. Molossid bats also show a great variation in the design of the echolocation calls, although little is known about the differences in foraging behavior. We have found evidence that upward frequency modulated echolocation signals have evolved in this family of bats in several independent instances, probably linked to an adaptation to foraging in background cluttered spaces in lineages with an ancestry of open space aerial insectivory. This transition in signal design may have been mediated by a constraint in flight morphology, and it may have opened new evolutionary pathways for the echolocation system. Signal design, neural processing capabilities, and flight performance are probably intimately interlaced in setting the pathways for the evolution of sonar systems.

Diet of the Long-fingered Bat, *Myotis capaccinii*, Nursery Inhabiting Miljacka II Cave, Croatia

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One of the biggest nurseries of the long-fingered bat in Europe inhabits Miljacka II Cave in the Krka National Park, Croatia. The number of bats estimated by tally counters and on photo image counts is about 6,000 individuals. The bats use the cave from May until the end of October. Although six other bat species use the cave during the same period of time, the interspecies spatial distribution is not overlapping. Pregnant long-fingered female bats group in the cave in late April/early May and deliver their young during late May/early June. Lactation continues until mid/end of July. From May–October 2000, bat droppings were collected every 15 days from beneath the colony by applying special netted stool. Overall 309 bat droppings were analyzed. The seasonal differences in diet composition as well as diet differences during pregnancy/lactation were established using frequency analysis. The overall diet consisted mainly of aquatic insects belonging to Trichoptera and Chironomidae. The exception was in October during which Chironomidae and Lepidoptera predominated. Also recorded were some Aranae that bats may have collected from water surfaces or spider nets while commuting to the nearby river. Other insects recorded in the diet were Ephemeroptera, Odonata (Zygoptera), Plecoptera, Orthoptera (Ensifera–Tetigonidae), Coleoptera (Chrysomelidae, Anthicidae), Diptera (Nematocera–Tipulidae, Mycetophilidae, Cecidomydae, Limoniidae, Simulidae, Culicidae, Sciaridae), Brachycera, Hymenoptera (Symphita–Ichneumonidae, Braconidae, Chalcididae, Formicidae), and Homoptera (Aphididae, Psyllidae, Cercopidae).

Conservation of Bats in the Veternica Cave, Croatia

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Veternica Cave located in the vicinity of the Croatian capitol Zagreb is managed by the Nature Park Medvednica. The cave is open for tourists. In order to minimize bat disturbance Nature Park ordered a 2-year research study from the Croatian Biospeleological Society that was conducted from the end of 2003 through mid-2005. In the Veternica Cave, 17 bat species have been recorded. Recent research confirmed the presence of 13 bat species, while during this project 12 bat species have been recorded. The cave is an important hibernation site for eight bat species: *Myotis blythii*, *M. daubentonii*, *M. emarginatus*, *M. myotis*, *M. nattereri*, *Rhinolophus hipposideros*, *Rh. euryale*, and *Rh. ferrumequinum*, which is in accordance with previous research. Occasionally, the cave is used by four other bat species during hibernation: *Barbastella barbastellus*, *Eptesicus serotinus*, *Plecotus macrobullaris*, and *M. bechsteinii*. The cave is an important summer roost for two bats species: *Miniopterus schreibersii* and *Rh. euryale*. For roost protection, special bat-friendly doors were constructed after the project was finished. The maximum number of *Rh. ferrumequinum* decreased approximately 40% in the last 10 years. In this research we found only solitary individuals of *Rh. euryale*, for which 130 individuals had been counted 10 years ago. The number of hibernating *Rh. hipposideros* bats increased four times. Compared to research undertaken 50 years ago, the number of bats in the *Miniopterus schreibersii* summer roost increased several times, while the numbers of bats in the *Rh. euryale* bat summer roost stayed the same. A short-term influence of visitors on the cave temperature has been recorded. Nature Park Medvednica can use the description of bat ecology, main characteristics used for bat determination, wing design of different species, and photo and video material in educational/promotional purposes and for bat monitoring. This is the first cave in Croatia officially closed for visits during bat hibernation.

Sensory Trade-offs at the Molecular Level: Olfaction in Echolocating and Non-echolocating Bats

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Since their discovery in rats over a decade ago, olfactory receptor (OR) genes have been detected in many orders of birds, fish, amphibians, placental mammals, marsupials, and monotremes. The value of OR genes to mammals is highlighted by the fact that they comprise the largest gene superfamily in the mammalian genome with more than 1,000 unique genes, comprising nearly 1% of the mammalian genome. Each OR gene codes for an olfactory receptor that binds to an odor molecule inducing a signaling cascade to the olfactory bulb in the brain. A sensory trade-off appears to have occurred whereby primates subjected to selection for color vision have a significantly higher level of pseudogenes in their OR repertoire than other primates that do not possess color vision. As a group, bats are nocturnal sensory specialists, inhabiting almost every echological niche on the globe, comprising echolocators and non-echolocators making them the perfect models to elucidate if this sensory trade-off occurs in other mammals with different sensory specializations. To investigate the genomic consequence of environmental niche specialization in bats, 100 OR genes were amplified and sequenced from a number of echolocating microbats and non-echolocating megabats. These genes were classified into class and family and the percentage of functioning and non-functioning olfactory receptor genes were examined to elucidate if a molecular ‘trade-off’ between olfaction and echolocation has occurred in bats.

Modeling Functional Landscape Connectivity in Bats: An Integrative Measurement of Landscape Structure and Movement Pattern

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Landscape connectivity may greatly influence the distribution of animals when it alters their movements and their ability to reach food patches. Depending on their foraging behavior, organisms may or may not adapt to anthropogenic changes in landscape connectivity and may eventually undergo local extinctions. Recent studies underlined the need to use indicators of functional landscape connectivity based on the behavior and movement abilities of studied animals to better link landscape structure to ecological processes in disturbed and fragmented areas. The objectives of this study were 1) to elaborate an index of functional connectivity for *Rhinophylla pumilio*, a Neotropical understory frugivorous bat, and 2) to use this index to investigate the possible mechanisms controlling its distribution and sustainability in a fragmented landscape. We pursued a 10-year bat mist-net survey, coupled to local estimates of food availability, in a mature forest of French Guiana that was recently fragmented by the completion of a reservoir lake. The 18 sampling sites range from undisturbed continuous forest sites to small remote forest fragments. A connectivity value, based on radio-tracking surveys, was attributed to each site. Connectivity measures mean forest cover within neighboring landscape units, weighted by the probability bats would use them, as estimated by frequency distribution of flight distance data. The abundance of *R. pumilio* was positively correlated with landscape connectivity and not correlated with local food availability. In spite of its high mobility, *R. pumilio* apparently failed to exploit a food resource that is distributed patchily over a low-connective habitat because its foraging movements are not well adapted to habitat disruptions.

Temporal Changes in Bat Community Structure along a Gradient of Forest Fragmentation: A Ten-year Survey in French Guiana

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The general objective of this study was to document the pattern of bat community changes in a recently fragmented, mature rainforest in French Guiana. The study area was flooded in 1994 by the completion of a hydroelectric dam that transformed 465 km^2 of initially continuous forest into a reservoir lake dotted with 100 km^2 of small forest remnants. Bats were mist-netted in 18 sites of various degrees of disturbance, both in the short term (years 2–4) and in the medium term (years 9–11) after the fragmentation occurred. Specific objectives were 1) to determine whether the changes in bat community structure are progressive along the disturbance gradient and intensify over time after fragmentation, and 2) to examine whether the effect of fragmentation is selective regarding diet and foraging pattern, by comparing trends among seven functional bat groups. For that purpose, we first performed a clustering classification of sampling sites using three descriptors of landscape structure. The most parsimonious classification yielded six classes of sites, delineating a consistent disturbance gradient. Second, using a null model approach, we showed that bat diversity tends to decrease along the disturbance gradient, down to only 40–60% of expected values. The sharpest temporal decreases were in sites of intermediate disturbance level. The decrease in diversity was binary rather than continuous along the disturbance gradient (unaltered vs. altered bat assemblages) but also involved sites of continuous forest bordering the disturbed areas. This raises questions about the risks of underestimating fragmentation effects when these areas are used as control sites. Overall, the diversity decrease is explained by the sharp decline in the abundance of nectarivores, understory frugivores, carnivores, gleaning insectivores, and small fig-eating bats, while the abundance of omnivores and of the largest fig-eating bats remained unchanged in space and time.

Reproductive Pattern of *Pteronotus davyi* (Chiroptera: Mormoopidae) in a Tropical Deciduous Forest of Western Mexico: Morphological and Histological Changes in the Female Reproductive System

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Details of the reproductive processes have been studied in only a few species of bats per one or more annual cycles. The aim of this work was to identify the reproductive pattern of *Pteronotus davyi* and study the morphological and histological changes that occur throughout the female reproductive system of *Pteronotus davyi* along an annual cycle. Five adult females were collected monthly (August 2003 to August 2004) in a *P. davyi* resident population living in "Cueva El Salitre", Los Ortices, and Colima, Mexico. The reproductive system was dissected (ovaries and uteri) and were processed through paraffin, serially sectioned at 6 micra, and stained with H-E. Measurements and anatomical and histological descriptions were made by means of photographs taken with a Stemi microscope sv-11, digital camera DXC 151A SONY, and the program 400 KS version 3.01. The analysis correlated the follicular maturation with changes of the uterus along the time. The results show that the female reproductive apparatus displays a short bicornuate uterus with a dextral asymmetry. Copulation happens between the second half of February and the beginning of March. Embryo implantation is central and antimesometrial. Placenta is discoidal morphologically and hemochorial physiologically. Gestation time was four months (March–June) and lactation two months (July–August). The reproductive cycle of the resident population of *P. davyi* in Los Ortices is monoestrus, monotocus, and is restricted to the first half of the year.

***Tadarida brasiliensis* as Control Agent of Potential Agricultural Pest and Disease Vector Insects in Nuevo Leon, Mexico**

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The ecologic and economic importance of the services provided by bats as pest control agents, seed dispersers, pollinators, and others is beginning to be recognized. This work presents the study of the food habits of a population of *Tadarida brasiliensis* during 2004 and 2005 summer seasons and a different remnant population of the same species during the 2004–2005 winter season, both in the center of Nuevo Leon State. The summer study identified a total of 53 groups of arthropods classified in 40 families belonging to 12 orders. This high diversity reflects the landscape mosaic and food offering of the area. Lepidoptera, Pentatomidae, and Cicadellidae were highest in frequency. The potential pest control of these insects by bats could be of benefit for tomato, vegetables, maize, sorghum, pecan, potato, citrus, and other crops as well as grazing pastures. On the other hand, the winter study identified 25 groups of 17 families in 8 orders, the highest volume and frequency of which were Lepidoptera, Aphididae, and Muscidae. Larvae of Lepidoptera cause damage to agricultural crops, stored seeds, and grazing pastures. Aphididade (Homoptera) are also fitophagus and disease vectors. The high proportion of representatives from Muscidae (Diptera) is relevant due to their role as vectors of diseases such as typhus and dysentery. The results of these studies could potentially be used as a conservation tool, since

protection of this bat species has an important effect on agricultural production, livestock, and human health.

Community Structure of Bats in the Tropical Forest of Oaxaca, México

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We studied the structure and composition of a community of bats in the Tropical Forest of Santiago Comaltepec, Sierra Norte, a high diversity zone located in the state Oaxaca, southern Mexico. We sampled bats using mist nets, five nights a month for ten months, from May 2006 to February 2007. Aspects studied were: guild structure, niche overlap, relative abundance, reproductive patterns, resident-migratory ratio, and biogeographic structure. Our total collection effort was 14,556 m x r x h. We captured a total of 364 bats from 18 species, belonging to two families (Phyllostomidae and Vespertilionidae). The most abundant species were *Dermanura tolteca* (147 individuals), *Sturnira lilium* (39), *Centurio senex* (36), *Carollia sowelli* (29), and *Glossophaga soricina* (29). Ten species were polyestric continuous, seven were polyestric seasonal, and one was monoestric seasonal. *Myotis californicus* was the only migratory species recorded in the locality. There was a predominance of Neotropical species (12), and six were Nearctic species. Frugivorous species dominated the community (14 species), followed by nectarivorous and insectivorous (2 species each). Forearm size followed a normal distribution. Our data did not show niche overlap in the community. There was no evidence that the observed structure can be due to randomness, so ecological or historical causes may explain the observed pattern in these communities.

Nectar and Pollen Use by Antillean Nectarivorous Bats

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Pollen and nectar are the main rewards offered by flowers to nectarivorous bats. Pollen grains provide protein but their cover is highly resistant to degradation. Nectar is a source of carbohydrates but it also contains large amounts of water that needs to be processed by the organism. We evaluated the extent to which three species of Antillean nectarivorous bats (*Monophyllus redmani*, *Phyllonycteris poeyi*, and *Brachyphylla nana*) relied on plant (pollen and fruits) and animal protein throughout the year in an evergreen forest in Cuba using nitrogen stable isotope analysis. We also determined digestion efficiency of pollen grains from *Talipariti elatum* (Malvaceae), *Agave desmettiana* (Agavaceae), and *Opuntia cochinellifera* (Cactaceae) by the three species of nectarivorous bat. Additionally, we determined intake response by *B. nana* fed glucose-fructose (GF) and sucrose (S) nectars at different sugar concentrations. On average, *M. redmani* (n = 39) and *P. poeyi* (n = 25) relied slightly more on plant protein (~60%) but in both species there were highly insectivorous individuals, and individuals that relied almost entirely on plant protein. *B. nana* showed the same trend but sample size was small (n = 4). The three species of bats were able to extract the contents of pollen grains offered but not with the same efficiency. *M. redmani* emptied a higher percent of grains (69–74%) than *P. poeyi* (49–56%) and *B. nana* (48–60%). *B. nana* did not compensate food intake for both GF and S nectars. The intake of this species was constrained when nectars were very dilute (5% sugar), which suggests that it is limited by the burden of excess water in nectar. Our study indicated that,

although Antillean nectarivorous bats are able to extract the contents of pollen grains, the stable isotope analysis showed that some individuals rely heavily on insects for protein. Finally, our study also indicated that when nectar reaches the lower end of sugar concentration found in bat-visited flowers, its consumption might be limited by processing of excess water.

Unusual Winter Mortality Events at Four New York Hibernacula During 2007
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Unusual mortality events were detected at four hibernacula in New York between early March and late April 2007. Bat carcasses and parts of carcasses were estimated to number in the thousands within Hailes Cave where this year's winter survey count of 7,296 live bats was 47% of the 2005 survey total. At Schoharie Cavern, 125 carcasses were found and the survey count of 478 live bats was 36% of the 2006 total. The number of carcass collected at Knox Cave (125) and Gages Cave (805) represent 20% and 83%, respectively, of the most recent winter counts. All of these caves are within a 12 km radius in Albany and Schoharie Counties, NY. With two exceptions that may be unrelated, there were no reported mortality events elsewhere in NY, VT, or PA. It is clear that many bats died outside of the hibernacula, and that mortalities began no later than early February. Winter submissions from the Albany County region to the NYS Health Department (DOH) of *Myotis* spp. were 10 times higher than mean submission rates over the last decade. Anecdotally, the number of observations reported by the public of bats flying in a wide variety of winter conditions was the highest in the experience of Department of Environmental Conservation (DEC) and DOH staff. Carcasses collected both inside and outside of Hailes Cave were emaciated, although necropsy results by pathology units at DEC and USGS are not yet completed. Many carcasses at Hailes and Schoharie had been predated or scavenged. We do not yet know the exact species composition of the kills, or the cause or causes of these mortalities, and investigations are continuing. We will discuss potential explanations including disease, and the possible relationship to record warm temperatures that occurred during the early winter.

Using an Acoustic Lure to Put Bechstein's Bat on the Map
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Bechstein's bat (*Myotis bechsteinii*) is considered to be rare throughout its distribution, and is identified as a priority species for conservation in both British and European legislation. Data on the habitat requirements and conservation status of Bechstein's bat are few, however, because it is an elusive specialist of mature broadleaved woodlands, and is very difficult to catch or record. We have developed a new method that uses an acoustic lure to attract bats into mist nets, greatly enhancing capture rates. Using this technique, woods in South East England were surveyed for Bechstein's bats in two phases. In Phase One a wide variety of woods were surveyed in order to test and refine our model of what constitutes suitable habitat for a breeding colony. Phase Two involved a comprehensive survey based on 10x10 km grid squares across the counties of East and West Sussex. Of the 44 grid squares in these counties, 12 had no areas of suitable woodland large enough to support a maternity colony. In the remaining 32 squares a wood matching at least 3 of our 4 criteria for suitable habitat was surveyed. Bechstein's bats were caught in 14 squares in West Sussex (8 female; 6 male) and 5 in East Sussex (1 female; 4 males). The survey supported our contention that, in this region, a breeding colony of Bechstein's bats requires a wood of > 75% canopy cover, with a high proportion of large oaks and more than 50% understory consisting largely of native species. By contrast, males are found in habitats that appear to be suboptimal. These may be as far as 40 km from the closest recorded maternity colony. A project is currently being developed to apply this technique to establish the entire distribution of Bechstein's bat in Britain.

Echolocation in Flight: Challenges and Solutions

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Movement of sound sources, reflectors, or receivers results in Doppler-shifts of the received sound signals. Bats with constant frequency echolocation calls (CF) have evolved intricate behavioral and physiological adaptations to evaluate such Doppler-dependent changes in the echoes' frequency for object detection, recognition, and speed measurement. Bats with frequency modulated calls (FM), however, lack such far reaching adaptations, and to them Doppler-shifts of echoes are mainly considered a source of ranging errors. Recently, an interesting link between such Doppler-ranging errors and another flight-induced ranging error has been suggested. This second error arises, because bats continue to fly while waiting for echoes to return to them, and thus hear echoes at a different place than where they emitted the call. It is in the nature of these errors, that they fully cancel each other at a certain distance from the echolocating bat. It is important that this distance depends on echolocation call design, in particular sweep rate, because this allows novel predictions with regard to distance-dependent signal design: e.g., during target approach, in a process similar to accommodation in vision, bats might adjust call design in a distance dependent manner such that objects of interest have no/low overall ranging error. Because of its analogy to accommodation, the call specific distance of zero ranging error has been called 'distance of focus' (DOF). The DOF can be deduced from recorded calls. We analyzed bats' echolocation behavior in the field with a focus on DOF and related it to the concurrent flight maneuvers with respect to structures in the environment (i.e., targets, obstacles) as monitored by acoustic tracking methods and laser scanning. We will present examples for DOF behavior in different behavioral contexts: search flight, commuting flight, obstacle avoidance, and target approach (flower).

Orientation and Navigation in Bats: Known Unknowns and Unknown Unknowns

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Until recently very little was known about the cues and mechanisms used by bats to navigate. Although it was known that bats had the ability to home to a roost from long distances and that migrants may be faithful to roosting sites from year to year, the way in which they were able to relocate these areas was not known. Over 50 years of research into the mechanisms of navigation in other animals, particularly birds, has provided possible cues that can be investigated in bat navigation. In the last year we have shown that big brown bats (*Eptesicus fuscus*) use a sunset calibrated magnetic compass to orient back to a home roost. Here we show by using the technique of pulse re-magnetization that the likely detection mechanism is a magnetite-based receptor. The first known unknowns in bat navigation are thus starting to be revealed. However, in both the sunset calibration experiment and the pulse re-magnetization experiment there is evidence for the bats having additional cues by which to orient, allowing them to either correct or ignore the faulty information given by the manipulated magnetic compass. There are still, therefore, unknown unknowns to discover in bat navigation.

On Flying Foxes in the Mediterranean Region

Ivan Horacek[1], Pavel Hulva[1], Radek K. Lucan[2], Sarka Havelkova[1], and Petr Benda[1,3]; [1]Charles University, Prague, Czech Republic; [2]University of South Bohemia, Czech Republic; [3]National Museum (Natural History), Prague, Czech Republic

The family Pteropodidae is restricted to Palaeotropic and Australian regions except for a curious extralimital range extension in the Eastern Mediterranean. In search of an explanation for that curious range extension we reexamined all records of the Mediterranean flying fox, *Rousettus aegyptiacus*, supplemented them with a number of new records from Cyprus, Turkey, Syria, Lebanon, Egypt, Yemen, and Iran, and collected samples for DNA analyses. The present contribution surveys some results with particular respect to history of its range in the region. Despite the Neogene records in the Western Mediterranean, the current range is restricted to the eastern-most part of the region and the zone of thermo-Mediterranean. The species is absent in all islands except for Cyprus. Genetic distances between local populations throughout the region (including Cyprus) are surprisingly low. In explaining this, we stress a close dependence of *Rousettus* on its ultimate winter diet—carob, *Ceratonia siliqua*—and dependence of its spread on the dispersal history of the latter. Given also that the uncommon fructification strategy of carob (cf. cauliflory, long fructification period timed to winter, olfactoric instead of optic signs of fructification, etc.) exhibits a strong adaptation to chiropterochory, we hypothesize that the Mediterranean ranges of both taxa evolved as a synchorological unit since onset of pronounced seasonality in the Late Cenozoic. The antropogenic spread of carob in the historical time also essentially affected the current range dynamics of the Mediterranean *Rousettus*, although, for more reasons, it responded it in the regional extent only.

Patterns of Bat Biodiversity Occurring within Residential, Parkland, and Remnant Bushland Habitats within the Urban Landscape of Brisbane, Australia

Clare Hourigan; Griffith University, Australia

The bat biodiversity of urban landscapes is poorly understood. Although bats are an important component of biodiversity, they are often overlooked and most of the information used to quantify biodiversity in urban areas originates from studies on birds. Such studies typically measure species richness alone. This overlooks the impact that variation in species composition between habitats can have on landscape diversity. Therefore the aim of this study was to investigate the beta diversity of the bat fauna occurring within an urban landscape. I investigated the species composition and evenness of four major habitat types within the city of Brisbane, Australia. I also compared variation in species composition between these habitats, and tested whether these patterns were significant. Forty replicate sites were split equally across each habitat type and sampled on six separate occasions. Sites from different habitats were sampled simultaneously using Anabat detectors. The recorded echolocation calls were identified to species using the bat call analysis system Analook, an identification key for the Brisbane region, and by consultation with bat call analysis experts. The frequency that each species occurred within each site was calculated by summing the number of nights (samples) in which a given species was recorded present at that site. Species were ordered from more frequent to less frequent in figures for each habitat and Brisbane overall to examine evenness. Multidimensional scaling (MDS) based on the replicated incidence based data was used to produce a similarity matrix, and an Analysis of Similarity (ANOSIM) was performed to determine whether patterns seen in the MDS were significant. Results and their implications will be presented at the conference. This research forms part of a larger study investigating the bat biodiversity of a large subtropical urban landscape.

A New Lineage in the *Pipistrellus pipistrellus* Complex from Europe (Crete, Greece)
Pavel Hulva[1], Petr Benda[1,2], Vladimir Hanak[1], and Ivan Horacek[1]; [1]Charles University, Czech Republic; [2]National Museum (Natural History), Czech Republic

In a model bat species, the common pipistrelle *Pipistrellus pipistrellus*, the species status of two phonic types was confirmed by application of molecular phylogenetics. The existence of peripheral populations in *P. pipistrellus* aggregate and their allopatric status brought a support for speciation driven by fragmentation of the range rather than sympatric speciation promoted by assortative mating and disruptive selection. Simultaneously, at least one new species in northern Africa was proved (*P. hanaki*). In present study we are adding further information by discovery of a new lineage of *P. pipistrellus* aggregate in the Mediterranean Basin, from the island of Crete (Greece). Molecular markers revealed that the Cretan lineage belongs to the *P. hanaki* clade, being separated from this sister taxon from Libya by a genetic distance of p = 4.2–4.5% in the cytochrome *b* gene. The application of species concepts, complicated by the geographical separation is discussed. The phylogeographic scenario comprehending faunal exchange between regions of Crete and Cyrenaica, connected with colonization event or changes in the sea level during the Messinian Salinity Crisis is presented and compared with the situation in Cyprus. The discovery of Cretan lineage represents further argument for importance of the Mediterranean region in phylogeny of the *Pipistrellus pipistrellus* species complex. This supplies the picture of diversification of clade containing the *P. pygmaeus* branch in the eastern Mediterranean, and supports the existence of an eastern colonization route and the hypothesis about episodic speciation between two main branches within the complex rather than their gradual change.

Ectoparasite Survey of *Leptonycteris curasoae* from Juxtlahuaca Cave, Guerrero, México
Nidia Inclán Espinosa, Juan B. Morales-Malacara, and Leopoldo Q. Cutz Pool; UNAM, Mexico City, DF, Mexico

The Cave of Juxtlahuaca is one of the most interesting cave systems in Guerrero State. It has a community of different bat species gathered in a room the “Salón del Infierno.” We did an ectoparasite survey from *Leptonycteris curasoae*, which has a moderate population in this cave. We collected *L. curasoae* at the different wet and dry seasons during the year 2004–2005. We took off all of the ectoparasite fauna from the bodies of all *Leptonycteris curasoae* (Lesser Long-nosed Bat). Bats were examined postmortem looking for ectoparasitic arthropods from the external body surface including the dorsal and ventral body, wings, tail membrane, ears, and nose. Mites were preserved in Hoyer`s medium and insects were preserved in 80% ethanol. Afterwards all specimens were counted and identified. We estimated relative abundance and

Shannon-Wiener index of diversity, evenness of Pielou, and Dominance of Simpson. We have found two species of Streblids—*Nycterophilia coxata* and *Trichobius spheronotus*—and four species of mites—*Periglischrus paracaligus* (Spinturnicidae), *Eudusbabekia provirilia* (Myobiidae), *Wagenaaria similis* (Leewenhoekiidae), and an accidental record of *Mesoperiglischrus natali* (Spinturnicidae). We found different ectoparasite abundance and diversity depending on dry or wet season, with high values in the dry season (561 and 0.6038), and low values in the wet season (8 and 1.213). And related with the Dominance and evenness indexes we found $\lambda = 0.6855$ and j' = 0.5530 in the dry season, and $\lambda = 0.25$ and j' =1.269 in the wet season. The abundance and diversity is affected for dominance of *N. coxata*. Additionally, regarding previous records of ectoparasites from *L. curasoae*, *W. similis* represents a new host record, if we consider that this chigger mite has been recorded from mormoopid bats and a few records from *Glossophaga soricina*. [Financial assistance was provided by the DGAPA, UNAM, Grant IN221906 to J.B.M-M.]

Fine-scale Kinematics of the Dog-faced Fruit Bat (*Cynopterus brachyotis*) Flying at Various Speeds

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Despite the fact that flight has been widely recognized as a key innovation for the ecological and evolutionary success of insects, birds, and bats, the basic mechanisms of generation of lift and thrust in animals are still poorly understood. In the past 40 years, flight models have used conventional fixed-wing aerodynamic theory to predict the generation of forces and energy use. This kind of analysis assumes relatively simple airfoil geometry, and it has been unable to fully explain how wings create enough lift to keep an animal aloft. The distinctive complexity of bat wing motion suggests that an adequate description of its kinematics is critical to understand the mechanisms of aerodynamic force production. A new understanding of animal flight has come through measurements of the dynamics of force generation by scaled physical models and computational approaches that were previously not possible. By using high-resolution, high-speed digital cameras we were able to reconstruct the 3D motion of body and wings of four individual dog-faced fruit bats (*Cynopterus brachyotis*) flying at speeds ranging from 2.6 to 7.5 m/s. We employ these data to test the hypothesis that wing kinematics change significantly with flight velocity. As speed increased, we observed slightly higher wingbeat frequencies and small changes in angles of attack, but no differences in wingbeat amplitude. Hindlimb motions are also substantial, particularly at high speeds, suggesting an active role in the control of the patagium. The subtlety of the observed changes with speed reinforces the idea that a detailed description of the three-dimensional motion of body and wings is essential for the study of bat flight.

Have Bats and Moths Co-evolved?

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The interaction between bat echolocation and moth hearing is often cited as an example of co-evolution. There is much evidence that moths have responded acoustically to bat echolocation by evolving the ability to hear the echolocation calls of bats and to take evasive action. However,

there is little evidence that the evolution of bat echolocation has been influenced by moth hearing as proposed by the Allotonic Frequency Hypothesis (AFH). Evidence in support of the AFH is in the form of a correlation between the peak frequency of bats and the proportion of moths in their diets. However, this correlation may not be indicative of a causal relationship between hearing sensitivity in moths and echolocation frequency in bats. First, phylogenetic analyses suggest that the high, and therefore potentially allotonic, frequency echolocation calls used by the Rhinolophidae are ancestral rather than derived and probably did not therefore evolve in response to moth hearing. Secondly, these high frequencies are not allotonic but are in fact audible to sympatric moths. We thus propose that the high proportion of moths in the diet of the Rhinolophidae may instead be a consequence of these bats hunting within vegetation where the evasive maneuvers of moths are less effective. Lastly, we provide evidence of acoustically mediated avoidance behavior in moths in response to bird predation. Moths are able to hear a bird landing on the bush on which the moths are feeding and take flight en masse effectively mobbing the bird. Thus audition in moths has evolved in the context of other predators besides bats making co-evolution between bats and moths unlikely.

Semiotics of an Advertisement Call of a Male Bat, *Pipistrellus nathusii*

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Acoustic stimuli are often expected to play an essential role in the social life of bats. Yet, the actual understanding of dynamics of social vocalization and semiotics of the social call remains restricted to few case studies (e.g., *Saccopteryx bilineata*). Here we report on results on Nathusius' pipistrelle (*Pipistrellus nathusii*), which is well known for a complex acoustic advertisement behavior performed by males either as song flight (SF) or sedentary display (SD). We analyzed phonologic, syntactic, and semantic characteristics of these calls based on 2,924 acoustic records obtained from individual males repeatedly occupying 33 roosts in Southern Bohemia from 1999 to 2006. Both SF and SD calls are composed of three main phonologically contrasting motives (A,B,C) and under specific contexts often supplemented with two accessory motives (D,E). Besides the major syntagmatic string ABC, we further recorded 15 syntagms containing the main motive A and 10 syntagms without this motive. In the peak of mating season and with SD, a complexity of the vocalization increases (a variation in syntagmatic structure and syllabic composition of particular motives as well as in length of syntagmatic strings). The motive A corresponds to advertisement calls of congeneric species related to agonistic vocalization, and B,C,D are specific for the studied species. B and C exhibit the largest between-individual but low within-individual variation, and their combination presents an acoustic signature of an individual and identified each particular male. Motive D corresponds to calls of mother-infant communication and shows the largest syllabic variation. Motive E is a series of steep FM signals evoking an act of landing. Thus the message of a complete advertisement call (ABCED) could be: "(A)–Pay attention, here is a *Pipistrellus nathusii*; (B,C)–I am a male XY; (E)–Land here; (D)–We share the common social identity and common communication pool."

The Bioactive Steroid Saponin 22-Methyl-*O*-protodioscin Was Isolated from Fruits of *Solanum rugosum*: A Preferred Source of Food for Phyllostomid Bats

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Fruits of *Solanum rugosum* (Solanaceae) are an important food source for bats of the genera *Sturnira* and *Carollia*. Because fruits of most Solanaceae plants contain large amounts of bioactive secondary plant metabolites, we were interested in the quantities phyllostomid bats are exposed to after consumption of *S. rugosum* fruits. For phytochemical analysis fresh fruits were harvested in Costa Rica (area of La Selva Biological Station) and the methanolic crude extract was subjected to preparative size exclusion chromatography (Sephadex LH20). The fraction containing high-molecular weight secondary plant metabolites was subjected to a preparative separation by 'high-speed counter current chromatography' (HSCCC). One of the resulting fractions was further purified by C_{18}-HPLC to yield the furostanol-oligoglycoside 22-methyl-*O*-protodioscin (3-*O*-[α-L-rhamnopyranosyl-(1→2)-{α-L-rhamnopyranosyl-(1→4)}-*ß*-D-gluco-pyranosyl]-26-*O*-[ß-D-glucopyransoyl]-22-methoxy-25(*R*)-furost-5-ene-3*ß*,26-diol). Structure elucidation of this novel compound was performed by a combination of 1D/2D-NMR spectroscopic analysis (HMQC, HMBC, TOCSY) and HPLC-ESI-MS/MS. Various pharmacological studies have shown that 22-methyl-*O*-protodioscin exhibits strong cytotoxic activities in human tumor cell models. HPLC-ESI-MS analysis with MS/MS experiments had shown the presence of chemotaxonomical relevant *Solanum*-steroid-alkaloides such as Solamargin, Solanin, and most likely Soladulcin or 23*S*-hydroxyanguivine. Thus far it is not understood how bats deal with the presence of potentially toxic, carcinogenic, or teratogenic secondary plant metabolites in the fruits they consume.

Strategies and Alternatives for Bat-related Control of Rabies

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Evidence of bat-related rabies could be traced to the Spaniard conquest of Mesoamerica, for which the old writings mentioned rabies and that vampire bats were responsible for its transmission. However it was not until the 1970s when detailed studies on the biology and ethology of the common vampire bat, *Desmodus rotundus*, identified it as the source of the rabies infection, and some control techniques were developed that are still in use in several Latin American countries. Since then, epidemiological and geographic analyses have enhanced the understanding, prevention, and control of rabies transmission; nevertheless, there is still much to study about the rabies virus–vampire bat relationship. Old and current techniques to control vampire bats will be reviewed, including oral vaccination of cattle and wild carnivores, impregnation of vampire bats with poisonous substances, diminishing the vampire bat population size, birth control programs for bats, among others. Much research has been undertaken within the past ten years, but some findings still are required to be put into a sanitary context; for example, the rabies virus phylogeny is better understood today, but such knowledge has not yet been reflected on the control methods as on virus translocation programs.

Foraging and Roosting Ecology of Indiana Bats (*Myotis sodalis*) in New York
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Although one of the most studied bats in North America, little data exist on the foraging and roosting habits of the federally endangered Indiana bat (*Myotis sodalis*) within the northeastern United States. Until recently, the majority of peer-reviewed research and habitat suitability models existed only for the core of the Indiana bat's range, and did not include the northeast states. Foraging and roosting data from the northeast are now beginning to emerge because of increasing knowledge of the species distribution in the region, much of which is due to recent conservation concerns over proposed wind energy developments. Because some of these developments exist in, or are proposed for, areas with known Indiana bat maternity colonies surrounded by a mosaic of food-producing habitats (early successional habitat, forested stands, agricultural areas, wetlands, and riparian areas), there is potential that these areas could represent quality Indiana bat habitat. To characterize habitats used by Indiana bats in north-central New York, we captured and radio-tagged male and female Indiana bats during the summers of 2006 and 2007. Nighttime activity, including habitat use and home range size, was assessed as well as selection of day roosts and roost-switching behavior. Data on Indiana bat foraging activity levels were also compared to local weather variables from a meteorological tower to assess the potential success of possible mitigation measures for existing or proposed wind energy developments. Data presented include an analysis of home range size and habitat use among sexes and reproductive classes, diet, and habitat analyses at roost-, stand-, and landscape scales near the periphery of the range of the Indiana bat.

Unravelling the Roles of Genetic and Cultural Factors in Determining the Development of Echolocation Call Frequency in Bats
Gareth Jones[1], Roger D. Ransome[1], Alice C. Huges[1], Jenny Taylor[1], and Stephen J. Rossiter[2]; [1]University of Bristol, UK; [2] University of London, UK

There is increasing evidence to support the hypothesis that call frequency in bats that use long, constant frequency components in echolocation is partly determined by imitation. We used extensive pedigrees of greater horseshoe bats, *Rhinolophus ferrumequinum*, based on microsatellite data to relate call frequency of offspring to the frequencies used by their mothers and fathers. We compared the heritability of a vocal trait with that of a morphological one. We predicted that call frequency would be influenced by maternal, but not paternal effects and that full sibs and maternal half-sibs would show close similarities in call frequencies, whereas paternal half-sibs would show limited or no resemblances. We also investigated age-related and seasonal changes in call frequency through analyses of longitudinal data.

iBats: Acoustic Monitoring of Bat Biodiversity at National and International Scales
Kate E. Jones; Zoological Society of London, United Kingdom

Biodiversity is being lost at an unprecedented rate in human history as the world population continues to grow and use a greater share of global resources. We urgently need to evaluate the effect of human development on our biodiversity and the benefits we obtain from ecosystems (e.g., clean water, flood and disease control, climate stability). However, basic information on

how species abundances and distributions change in response to development is lacking for most areas and species. Bats show the potential to be useful biodiversity monitoring indicator species as they are distributed globally, use a wide range of landscapes, and play an important role in ecosystem functioning (controlling insect populations, pollination and dispersing seeds), and their population declines reflect changes in climate, water quality, and agricultural practices. Here I present an innovative method for monitoring bat biodiversity at national and international scales to generate data on changes in bat species distributions and abundances to evaluate the impact of global change on biodiversity. Specifically, I develop methods for collecting acoustic transects of bat ultrasonic echolocation calls along roads and demonstrate the feasibility of this approach with preliminary results from annual surveys carried out between 2005–2007 in the United Kingdom and Eastern Europe.

Above Concrete and Tree Canopies: A Comparison between High Flying Insectivorous Bats in Urban Areas versus Mature Forest in Panamá Using Acoustic Monitoring
Kirsten Jung[1] and Elisabeth K. V. Kalko[1,2]; [1]University of Ulm, Germany; [2]Smithsonian Tropical Research Institute, Panama

Aerial insectivorous bat species are highly mobile animals and swift flyers that react quickly to changing environmental conditions. We used acoustic monitoring to investigate the composition, dynamics, and activity of high flying aerial insectivorous bats foraging above the canopy (open space) and along forest borders (edge space) in Panama. We identified echolocation calls to species level by using a call library established at the University of Ulm, Germany. The different acoustic monitoring sites were distributed along a steep anthropogenic gradient from mature forest to the heavily populated Panama City. On a regional scale we investigated if species composition and abundance of aerial insectivorous bats differ between sites and determined factors that are the main drivers for the observed differences between mature forest and urban areas. Furthermore, we assessed short-term (e.g., moon phase) and long-term (seasonal) effects on abundance and activity patterns of the aerial insectivorous bats. We expected less variability in the city because of its rather stable, primarily hot and dry climate, throughout the year. Furthermore, we predicted that the large number of streetlights and artificial illumination in general are likely to mask possible effects of the moon on activity. On a local scale, we recorded aerial insectivorous bat species while they were foraging around streetlights in the small town of Gamboa situated in the middle of the disturbance gradient from mature forest to the city. We found distinct differences in species composition of aerial insectivorous bats compared to the city. Probably because of the proximity of Gamboa to the mature forest of the adjacent Soberania National Park, we found a number of forest species—normally not found in urban environments—that were foraging around the streets lights. We interpret our results in light of ecological and conservation-oriented aspects.

Bat Activity in the Boreal Forest: Short-term Effect of Fire and Fire-created Edges on Habitat Use by Little Brown Bats (*Myotis lucifugus*) in Northwestern Canada
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Fire is one of the most pervasive disturbances in the boreal forest, with vast tracts of habitat being burned each year. Yet, the effect of fire on habitat use by many species is unknown. Bats are one group of species that may benefit from habitat modifications resulting from fire because the reduction of vegetative clutter may increase foraging opportunities, and because fires often create abundant snags (standing dead trees), which may increase roosting opportunities. During June to August 2005, activity levels of little brown bats (*Myotis lucifugus*) were acoustically monitored at lacustrine and upland sites in burned and mature boreal forest, using AnaBat II ultrasonic detectors. Using a blocked sampling design, I monitored eight replicates of each of four treatment types. Activity levels were significantly greater in unburned forest than in burned forest, both at upland and lacustrine sites. The relative use of edges created by fire, and those created by lakeshores and road corridors, was also investigated using remotely deployed AnaBat II detectors. In this study, six sampling sites for each of the three edge-type treatments were sampled. Bats used edges at lakeshores significantly more than fire-created edges or edges created by roads. Similar to logged stands elsewhere in the boreal forest, little brown bats avoided these very open habitats. Thus, large areas of burned boreal forest appear to provide little foraging habitat for little brown bats, despite the reduction of structural clutter and creation of abundant snags. Distinct edges created by fire, however, may be useful to little brown bats as travel corridors and foraging habitats. This work is a first approximation of the use of burned boreal forest by bats; more work is needed to examine the influence of fire severity and time since fire on habitat use by bats in the boreal forest.

Adaptability and Functional Significance of Echolocation Behavior in Bats (Symposium Synopsis)
Elisabeth K. V. Kalko; University of Ulm, Germany; Smithsonian Tropical Research Institute, Panamá

Studies on echolocation behavior of bats continue to flourish with the advancement and practicability of high-quality sound recording and analysis methods as well as exciting expansions of our conceptual background where variability of signal design is set now into much broader perspectives than before. This symposium aims at bringing together a selection of the latest approaches in echolocation research with the main goal to link variability in signal design to 1) functional significance (i.e., spatial orientation, foraging); 2) genetic as well as cultural background; and 3) evolutionary history. Most of the studies focus on performance and use of echolocation by bats for specific tasks that are either addressed in behavioral studies in the field or under controlled laboratory conditions. As newly emerging fields, modelling approaches are proposed and behavioral studies on the performance of foraging bats are presented that unravel flexibility in echolocation behavior and information processing as essential factors contributing to resource partitioning. A thorough understanding of a wide range of factors influencing signal design in bats is indispensable to evaluate its variability in an ecological and evolutionary framework.

See Me, Feel Me, Touch Me, Hear Me: Sensory Ecology of Neotropical Bats
Elisabeth K. V. Kalko, Institute of Experimental Ecology, University of Ulm, Germany and Smithsonian Tropical Research Institute, Panamá

One of the most intriguing patterns in bat diversity is the astounding high number of species in the Neotropics. In addition to historical factors, taxonomic richness and the development of flight, the use of various senses represents a major key of success as it gives bats almost unhindered access to a multitude of resources at night. Here, the use of echolocation, vision, scent, touch, heat, and listening to prey-produced noises offers many ways for finding and acquiring different types of foods ranging from blood, small vertebrates and arthropods to nectar, fruits, and leaves. In my talk, I am summarizing our current knowledge on the sensory basis of food detection, classification, and localization of Neotropical bats with special emphasis on recent findings. Examples range from fast-flying aerial insectivorous bats that dart through the sky thereby tracking flying moths and beetles in clutter-free, three-dimensional space to bats that succeed in finding wingless walking sticks and motionless dragonflies sitting on leaves within the vegetation as well as to bats that pounce on rustling or calling prey on the ground, "sweep-off" insects from surfaces or sniff out fruit in dense forest. Undoubtedly, the combined use of sensory cues as well as fast learning abilities have opened up the resource-rich tropical rainforest to the endemic family of New World leaf-nosed bats (Phyllostomidae), whereas other bat families (i.e., Molossidae, Vespertilionidae, Mormoopidae) appear to be more constrained, both in maneuverability and sensory capacities. However, the evolution of a very rich echolocation call repertoire among bats foraging in the open and at edge spaces lead to a much higher variability in call shape than expected. This variability is likely to be one of the causes underlying the much greater richness of these functional groups in the tropics in comparison to temperate zones. Given the recent advances in technologies, easier access to a wide range of different study areas and a much more refined conceptual background, we are in my opinion right at the beginning of a fascinating and instructive journey into the sensory world of bats with the ultimate goal to add to the deeper understanding of mechanisms that promote the high species richness in this group and its physical and biotic interactions with their environment.

Alternate Strategy of Mating by a Solitary Male in the Polygynous Tent-making Bat *Cynopterus sphinx*

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Breeding colonies typically consist of a few harems with one or more solitary males nearby. Essential to understanding the mating system of *C. sphinx* is identifying the reasons for solitary roosting behavior in adult males. In this study, we attempt to elucidate the impetus behind solitary roosting by investigating the following questions. Are trees and foliage suitable for tent-making a scarce resource? Are solitary males less competitive and so remain isolated from the breeding activities? However, the conditions and mechanisms under which non-harem males become harem males are not understood fully. We carried out weekly censuses, mark-recapture, and radiotelemetry studies in and around Madurai and Palayamkottai, Tamil Nadu, South India. Our results suggest that female aggregation in *C. sphinx* cannot be attributed to scarce resource. Comparison of morphological variables between harem and non-harem males showed no significant difference. Approximately 50% of non-harem males had scrotal testes. Moreover, the transition of non-harem male to harem male status possibly by a previously unobserved mode and the female recruitment is associated with resource (roost). These results suggest that the non-harem males are actively involved in female recruitment and also presumably mating.

Artificial Bat Roosts and Seed Dispersal: A Method to Enhance Forest Restoration

Detlev H. Kelm and Otto von Helversen; Institute of Zoology II, Berlin; University of Erlangen, Germany

Today, extensive regions in the Neotropics are dominated by agriculture, mostly comprising plantations and cattle pastures. When agriculture becomes uneconomical, land is frequently abandoned and subsequent natural habitat regeneration may be slow due to restricted seed dispersal. Increasing environmental awareness has encouraged efforts to promote reforestation. However, practical and cost-efficient methods of kick-starting forest regeneration are lacking. Frugivorous bats are key seed dispersers in tropical habitats. Some of these bat species can occur at high densities in agricultural habitats, provided suitable roosts are available. Logging, however, results in a scarcity of natural tree roosts, which may consequently restrict bat populations and, in the long run, seed-dispersal. We installed artificial bat roosts for frugivorous bat species in primary forest, as well as in agricultural habitat and monitored seed rain around artificial bat roosts and in adjacent areas. Colonization of artificial roosts by frugivorous and nectarivorous bats was fast and permanent in both primary and agricultural habitats. In total, ten bat species colonized the artificial roosts. Seed dispersal around those roosts was increased and we identified 69 different seed types that are transported by bats to the artificial roosts in agricultural habitats, most of which were fast growing pioneers. We conclude that the installation of artificial bat roosts can attract seed dispersing bats into fallow land and may thus help to overcome initial barriers to forest restoration.

Impact of Bt (*Bacillus thuringiensis*) Crops on Bat Activity in South Texas Agroecosystems

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A growing body of evidence illustrates the ecological and economic impact of Brazilian free-tailed bats (*Tadarida brasiliensis*) as consumers of important agricultural pests in South Central Texas. However, the face of modern agriculture is rapidly changing. The widespread adoption of transgenic Bt (*Bacillus thuringiensis*) crops, purported to kill up to 95% of target pests, raises concerns that non-target species may be harmed and food webs disrupted. Most studies of non-target effects of Bt crops focus on insect predators in controlled settings, and we know little about effects on higher-level predators *in situ*. During the growing season of 2006, we used a combination of ultrasonic monitoring, video imaging, and insect sampling in four farms containing both Bt and conventional crops to determine the extent to which bats track the availability of insect pests and how Bt crops influence bat foraging activity. Mean numbers of calls recorded from 2100–2300 h varied among sites and ranged from 1,790 to 5,221 calls, but was greater at all sites during periods of local insect emergences from crops, with an average of 2,063 calls recorded prior and 4,285 calls recorded post insect emergence. Fewer calls were recorded over Bt fields, especially during these periods of local insect emergences (2,931 calls over Bt compared to 5,894 calls over non-Bt). These preliminary results suggest that bat foraging activity may be negatively impacted by the presence of Bt crops during times that coincide with high energetic demands, including lactation in mid-summer and preparation for migration in late summer. Although bat activity was not generally correlated with nightly insect counts from pheromone traps, we are evaluating other insect abundance measures including moth counts

from video imaging over the Bt and non-Bt fields. In addition to documenting the pest control services provided by bats, this study has conservation implications for declining bat populations. The results may extend beyond foraging bats in Texas, as the use of Bt crops increases and broader ecological impacts remain largely unknown.

The Influence of Forest Fires on the Bat Community in Boca del Cerro, Tenosique, Tabasco, Mexico

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Forest fires have an effect on the decline of great vegetation expanses, which in turn reduces habitat availability for several species of mammals. The objective of this study was to analyze the impact forest fires have on the bat communities of Boca de Cerro, Tenosique, Tabasco, Mexico. Six vegetation types were selected: acahual and rainforest (before the fires), perturbed and not perturbed acahual and rainforest (after the fires). For each vegetation type, two nets were used to capture bats. The fieldwork lasted 22 months, and was divided into 2 periods: 11 months before and after the fires. Richness, diversity, and similitude between vegetations were obtained and 4 families with 26 different species were registered. The number of species registered in each vegetation type was 17 in the rainforest, 16 in the acahual, 12 in not perturbed rainforest, 14 in perturbed rainforest, 11 in not perturbed acahual, and 15 in perturbed acahual. The highest diversity was obtained in the rainforest before the fires (6.04), and the lowest in not perturbed acahual (3.42). The highest similitude was between the perturbed acahual and the rainforest and acahual (1.00), and the least similar were the not perturbed acahual and rainforest (0.83). Of the registered species, *Myotis keaysi* was only found in the acahual before the fires. In the not perturbed rainforest *Micronycteris brachyotis* and *Mimon crenulatum* were captured; in the perturbed acahual *Dermanura watsoni*, *Desmodus rotundus*, and *Myotis nigricans* were found, while in the perturbed rainforest only *Pteronotus davyi* was registered. Five species that are considered at risk by the NOM-059-SEMARNAT-2001 were recorded: *Micronycteris brachyotis, Mimon crenulatum, Dermanura watsoni, Mimon bennettii,* and *Trachops cirrhosus*. Forest fires modified the structure of the bat communities, although in the regeneration process of the perturbed sites, some of the species found before the fires started to return.

Bat Conservation in Southeast Asia

Tigga Kingston[1], Allyson Walsh[2], Paul Bates[3], Matthew Struebig[4], Thomas H. Kunz[5], and Zubaid Akbar[6]; [1]Texas Tech University, USA; [2]Lubee Bat Conservancy, USA; [3]Harrison Institute, United Kingdom; [4]University of London, United Kingdom; [5]Boston University, USA; [6]Universiti Kebangsaan Malaysia, Malaysia

Heavy deforestation in progress in Southeast Asia is expected to lead to the extinction of many bat taxa, with upper-bound estimates of regional species losses exceeding 40% and global extirpation anticipated for at least 23% of Southeast Asia's bat fauna by 2100. Many of the larger flying foxes are intensively hunted for bushmeat and traditional medicine. Global climate change is likely to further exacerbate losses, altering spatial and temporal patterns of resource availability that define habitat use and reproduction, and consequently the survival of bat populations. With over 125 species, Malaysia is at the very center of paleotropical bat diversity and a critical country for international bat conservation. In 2001, the Malaysian Bat Conservation Research Unit (MBCRU) was established to promote the conservation of the country's unique bat fauna through a program of conservation research, capacity building, and outreach. The success of the MBCRU model led to the launch of the South East Asian Bat Conservation Research Unit (SEABCRU) in 2007, in order to identify region-wide conservation research priorities, implement standardized research protocols to address these priorities, build capacity of young SE Asian researchers, and to develop and implement outreach programs. Here we present the key achievements of the MBCRU in its first five years, and detail the research priorities identified at the SEABCRU launch meeting at the First International South East Asian Bat Conference in Phuket, Thailand 2007.

Dietary Analysis of Five Species of *Myotis*: Does Reproduction Affect Diet?

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Insectivorous bats must fly among or around vegetation to find prey, and efficient aerial foraging requires low body mass, large wing area, and low wing loading. Increased weight associated with pregnancy and therefore increased wing loading could potentially affect the type of prey pregnant females are able to capture by affecting maneuverability during foraging. Pregnancy and lactation in females are very energy demanding and there is some indication that females are calcium stressed during these times and need to eat 3.5–7 times their normal required energy and select calcium rich prey. If maneuverability is decreased due to increased wing loading, then the diet of reproductive females might be affected. Fecal samples were collected from 38 *Myotis volans*, 90 *M. evotis*, 35 *M. thysanodes*, 39 *M. lucifugus*, and 16 *M. ciliolabrum* captured at eight water holes located around Boulder, CO. Fecal pellets of individuals were teased apart in warm water with a sharp probe and insect parts were identified to order using taxonomic keys. The total number of insects per order was calculated for each group as well as percentage of total consumption. Chi-squared tests were run to determine if diet differed between males, pregnant females, and non-pregnant females for each species. Diet did not differ significantly between males, pregnant females, and non-pregnant females of any of the five species. A correlation test was also run to determine if a relationship between wing loading and number of insect orders eaten existed. The test showed no significant relationship between wing loading and the number of different insect orders eaten ($r = -0.04$, $r^2 = 0.0017$). It is possible that difference in diet are not seen by this but exist at the family or species level. More research is needed to determine if diet between the groups differs at the family or species levels for insects consumed.

Isolation Calls and Their Occurrence during Vocal Repertoire Ontogeny in the Greater Sac-winged Bat, *Saccopteryx bilineata*

Mirjam Knörnschild and Otto von Helversen; University Erlangen-Nuremberg, Germany

Acoustic analyses of isolation calls of wild *Saccopteryx bilineata* pups revealed individual signatures, which are likely to facilitate acoustically mediated mother-offspring recognition. We verified this finding through playback-experiments in which mothers were exposed to the recorded isolation calls of their own pup and an alien one. Mothers clearly discriminated between own and alien pups and responded stronger to the former. We also conducted playback-experiments in which pups were exposed to the recorded echolocation calls of their own and an alien mother. Pups responded indiscriminately to the echolocation calls of both own and alien mother. Apart from facilitating mother-offspring recognition, isolation calls also occurred during the ontogeny of the species-specific vocal repertoire. To acquire the relatively large adult vocal repertoire, pups engaged in so-called babbling behavior. Pups produced renditions of all known adult vocalization types and mixed them with isolations calls during bouts of vocalizations. These babbling bouts appeared to be uttered independently of a distinct social context but may enhance maternal investment towards the babbling pup.

Resource Use and Foraging Strategy in Cuban Flower-visiting Bats: *Phyllonycteris* and *Monophyllus*
Corinna U. Koch and Otto von Helversen; University of Erlangen, Germany

Cuba is the largest island of the Greater Antilleans with a diverse flora and fauna, largely dominated by endemic species. Five species of bats visit flowers—some only occasionally—and the two most specialized groups are the phyllonycterines, mainly *Erophylla sezekorni* and *Phyllonycteris poeyi*, and the only glossophagine bat *Monophyllus redmani*. We compared the flower visiting behavior of the two subfamilies, the phyllonycterines and the glossophagines, and revised the Cuban angiosperm flora for bat pollinated plants and examined them for their adaptations to the two modes of exploitation: *Phyllonycteris* is unable to hover, but very agile on foot, with extremely elongated legs, always landing on inflorescences and staying there for up to five or ten minutes. *Monophyllus* is perfectly able to hover and visits flowers hovering in front of them for often less than half of a second. *Phyllonycteris* is group foraging and visits mainly the flowers of palm trees, especially the “Royal Palm” *Roystonea regia*, and some other large flowered more generalistic trees like *Taliparites* (*Hibiscus*) *elatus*, both endemic to the Antilleans but widely distributed there. *Monophyllus* forages solely. It exploits a great number of flowers highly adapted to bat pollination, of the genera *Gesneria*, *Rhytidophyllum*, *Lobelia*, *Caesalpinia*, *Samyda*, *Schmidtottia*, *Ceuthocarpus*, *Helicteres*, *Adenoa*, etc.—many of them hitherto unknown to be bat pollinated. All of these species are endemic to the Greater Antillean islands and must have evolved their chiropterophily under the selection of *Monophyllus*, the only hovering, small glossophagine bats of the Antillean islands.

Use of Echo Information for Adaptive Foraging
Klemen Koselj[1,2], H.-U. Schnitzler[1], and Björn Siemers[2]; [1]University of Tübingen; [2]Max Planck Institute for Ornithology, Germany

Every animal lives in its subjective world (Umwelt sensu von Uexküll). The acoustic world of echolocating bats is especially hard for us to imagine. For example, it is hardly possible to disentangle the influences of bats’ prey selection strategies and perceptual constraints on the composition of these animals’ diets in field studies. We developed a simulation of greater horseshoe bats’ foraging Umwelt in the lab drawing from the data on the specialized echolocation system (Doppler shift compensation and acoustic fovea) used by these bats for the detection and discrimination of fluttering insect prey. We used computer-controlled propellers to manipulate the echo information available to the bats. We recorded bat echolocation calls and echoes of differently sized rotating propellers. Their frequency-time structure resembled the echoes of ensonified fluttering insects of different body sizes. During the first experimental trials bats spontaneously tried to attack the rotating propellers confirming their convincingness as prey cues. Bats also spontaneously associated these cues with the size of rewards (i.e., mealworms presented at propellers). We varied the availability of different prey size classes by manipulating their relative proportions and time intervals between successive presentations in a foraging session. The bats adapted the level of selectivity to the availability of more profitable prey items as predicted by foraging theory. We found pronounced individual variation in the minimum encounter rate of large prey at which the bats rejected any small prey items presented during a foraging session. Within individuals, the outcome of foraging decisions also depended on the current state of energetic reserves. Our results are the first experimental evidence for echolocation-based adaptive foraging decisions in insectivorous bats.

Management Recommendations for Bat Conservation in Forested Landscapes of Eastern North America

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Populations of most bat species in eastern North America are believed to be declining. Causes of decline include habitat loss or adverse modifications and vandalism at hibernacula. In an attempt to reverse declining population trends, the U. S. Forest Service manages forested landscapes to conserve bats. Cliffline habitats important to rare bat species are protected with a 30-m buffer above and 60-m buffer below the cliff face. Management occurring in buffer zones is done to benefit cliffline dependent species. Caves and mines are assumed to be occupied by federally threatened or endangered bats and protective measures are implemented until it is proven that these sites are not important to listed bats or large concentrations of any bat species. Buffer zones ranging from 400 m to 8 km are placed around caves and mines depending on species present, location, and season of year. For example, prescribed fire is prohibited within 8 km of Indiana bat (*Myotis sodalis*) hibernacula during the fall swarm, to protect and avoid disturbing roosting bats. Gates or other structures are constructed and maintained at entrances of important hibernacula to minimize human disturbance. Before old buildings and other man-made structures are modified or demolished, they are surveyed for bats. If significant bat roosting is found within such structures, these structures are maintained or alternate roosts suitable for the species and colony size are provided before their adverse modification or destruction. Usable water sources are provided across the landscape. Forested corridors are maintained along watercourses including channeled ephemeral drains. All immediately suitable roost trees are retained in timber harvest activities. Managed forests provide older, larger trees with canopy gaps, open understories, and a diversity of structure across the landscapes. These basic concepts could apply to any forested landscape. A sustainable flow of habitat through time is critical.

Batting through the Eyes of a Thirteen-year Old

Jamie Krusac; Durham Middle School, Acworth, GA, USA

Not many adults know about bats and even fewer young people do. I was lucky because my dad worked with bats, and I learned about them at an early age. My dad caught on to the fact that I liked bats and started taking me to see them. The first bat I touched was at the Cincinnati Nature Center, with Jackie Belwood, in first grade. When I got home, I started to lie in the driveway and watch the bats forage around the streetlight. I went to the Kentucky Natural History Society meeting and met James Kiser and John MacGregor. They took me into a cave and let me hold a *Pipistrellus subflavus*. In 2006, my dad took me to the Southeastern Bat

Diversity Network Bat Blitz. The Blitz occurred in the mountains of South Carolina and Georgia, where I met two more of my dad's friends, David Saugey and Matina Kalcounis Ruppell, who taught me how to get a bat out of a net and how to process them. We caught some rare bats including a *Corynorhinus rafinesquii*. I helped Matina light-tag *Myotis leibii* and *Eptesicus fuscus* and record their sounds for a call library. We released the *E. fuscus* into an old pasture where it immediately began foraging, allowing us to record multiple calls and feeding buzzes. During the 2006 Bat Blitz, 32 sites were surveyed and 261 bats (representing 10 species) were captured. Included in the total was a *Lasiurus seminolus*, which was a new county record. All of my dad's friends taught me like I was an adult, not a child. Their teachings will greatly help me become a future bat biologist.

Determining Pregnancy in the Field Using Ultrasound

Allen Kurta and Rodney Foster; Eastern Michigan University, Ypsilanti, MI, USA

Quantifying reproductive effort is an important aspect of population ecology and provides essential information for successful management of any species. Determining pregnancy in living bats, however, is difficult and typically relies on simple palpation of the abdomen. This technique often is unreliable because results can vary with factors such as experience of the investigator and amount of food present in the digestive tract of the mother. Furthermore, palpation typically is not useful until the latter third of pregnancy when embryos have reached sufficient size to be felt externally. In this study, we demonstrate use of a portable ultrasound device to determine pregnancy in the 8-g little brown bat (*Myotis lucifugus*) and the 16-g big brown bat (*Eptesicus fuscus*). Our instrument, designed for use with humans, is powered by a rechargeable battery, weighs only 600 g, and is easily carried in a backpack, making it practical to use the instrument in the field.

Scaling of Body Size and the Abdominal Wall in Echolocating Bats

Winston C. Lancaster and Ishtar Thomas; California State University Sacramento, Sacramento, California, USA

By the principle of Laplace, the pressure generated within a cylindrical muscular organ is related to the stress produced by its walls and its radius. Progressively larger cylinders require greater stress to generate equivalent pressures. Pressure is generated by the stress exerted by muscular walls and is determined by the thickness of the wall. Therefore, generation of equal pressures in progressively larger cylinders requires thicker walls. If applied to bats that produce intense vocalizations, the principle of Laplace would predict that the muscles of the abdominal wall, the generators of pressure for echolocation, should become disproportionately thicker in larger species. This requirement could then limit the size of high-intensity echolocating bats by the practical limits of the thickness of a muscular body wall. From measurements on 38 species (13 families) of alcohol-preserved bats from the collections of the Royal Ontario Museum and the American Museum of Natural History, we estimated body volumes, and the cranio-caudal length of the abdominal wall. Samples of the abdominal wall were collected to measure thickness and examine the structure of the muscle. Cross sectional area of abdominal wall muscles determines the power available to compress the thoracoabdominal cavity. The cross sectional area of the muscles of the abdominal walls of bats that use high intensity echolocation increase in relation to body volume at a higher rate ($y = 0.257x^{0.67}$, $R^2 = 0.64$) in comparison to bats that use low intensity echolocation or are non-echolocators ($y = 0.133x^{0.40}$, $R^2 = 0.37$). This suggests that the demands of high intensity pulse production require a greater thickness of the abdominal wall. Our data indicate that the cross sectional areas of the abdominal walls of bats that use high intensity echolocation increase normally in proportion to body volume. Despite great variation, the rate of increase in cross sectional area of the abdominal wall in non-echolocating and low intensity echolocating bats is lower than would be expected for normal allometric relationships. This could be an adaptation for reduction in body mass.

The Bat Jungle — Commercializing Bat Conservation in Costa Rica (Video)

Richard K. LaVal; The Bat Jungle, Monteverde, Costa Rica

The Bat Jungle is a recently opened ecotourist attraction located in the popular tourist destination of Monteverde, home of the famous Monteverde Cloud Forest Preserve and The Children's Rainforest. The Bat Jungle is housed in a large, modern and attractive building on the main road in Monteverde. The focus of The Bat Jungle is to educate the public in bat biology and conservation in an entertaining way, using trained guides, a series of professional posters designed by myself, interactive and unique exhibits, and a 17.5 m long bat flyway designed to resemble a cloud forest at night. Approximately 67 tropical fruit and nectar bats of 8 species fly, forage, roost, and socialize within 1 to 2 m of the visitors, who are on the other side of huge slanted glass windows. The bats are kept on a reversed day-night regime so they are active at the times tourist visitors normally arrive. The guided tour is offered free to groups of children from local schools, as well as local residents. Students and Costa Rican tourists enter at reduced prices. At this time the Programa para la Conservación de Murciélagos de Costa Rica is gearing up to use the facility in its environmental education program for grade school children. A modern auditorium with up-to-date audiovisual equipment and surround sound offers a place for various educational activities, as well as a theater to show the latest professional videos about bats. I add that great bat photos by Merlin Tuttle, Marco Tschapka, myself and others are used throughout the exhibits. For a closer look go to the following website: **http://paseodestella.googlepages.com/home** and check out the home page, the Bats page, and the Bat Jungle Exhibits page.

Ant-eating Bats

Eran Levin[1], Anat Barnea[2], and Yoram Yom-Tov[1]; [1]Tel Aviv University, Tel Aviv, Israel; [2]The Open University, Raanana, Israel

Several thousand of the Larger and Lesser Mouse-tailed Bats (*Rhinopoma microphyllum* and *R. hardwickei*) migrate to the Mediterranean areas of northern Israel during summer (the northern range for these species). Their energy demands during this period are thought to be very high as they accumulate large amounts of fat, and females give birth and nurse the pups. We studied the diet of these bats during summer months by fecal analysis. At the beginning of summer beetles (Coleoptera) comprise the major part of the bats' diet, but surprisingly, from July until October, large (15 mm) ant alatas (winged forms) of the large carpenter ants *Camponotus fellah* and *Camponotus sanctus* account for a major portion of the diet of these bats (up to 90% volume). In temperate latitudes, nuptial flights of ants are known to be brief, usually synchronized with meteorological conditions such as first rain or an extremely hot day. However, by analyzing the bats' diet we documented nocturnal nuptial flights of ants, happening every night during summer months. These kinds of nuptial flights have not been reported before. Ant alatas are a very high quality food, rich in fat and protein, and their composition may also be important for females during lactation and for both species in pre-hibernating fat storage. No such high fraction of ants has been found in the diet of other bat species in the same area. This high quality energy resource may explain the annual migration of these bats.

Historical Biogeography of New World Emballonurid Bats
Burton K. Lim; Royal Ontario Museum, Toronto, ON, Canada

The objective of this study is to reconstruct the biogeography of New World emballonurid bats (tribe Diclidurini). Although bats are the second most speciose order of mammals, they have not substantially contributed to our understanding of historical biogeography in the Neotropics because of a poor fossil record and lack of species-level phylogenies. In addition, being the only group of mammals that fly, bats typically have large distributions with relatively few species endemic to restricted areas that are amenable to vicariant biogeographic approaches. Phylogenetic analysis for comparing trees (PACT) is a new algorithm that incorporates all original spatial information from taxon area cladograms into a general area cladogram. There were nine biogeographic areas identified in Central and South America for emballonurid bats. Molecular dating was used as an additional component to cover the temporal aspect of historical biogeography. The general area cladogram from PACT indicated that within-area events and not vicariance was the major mode of speciation for New World emballonurids because the ancestral area at most nodes based on character optimization was the Northern Amazon. Geological history combined with fluctuations in temperature and sea level suggests micro-allopatric within-area speciation in a changing and heterogeneous environment in the Northern Amazon during the Miocene. This situation is similar to the taxon pulse hypothesis of biotic diversification where there are repeated episodes of range expansions and contractions from a stable core area such as the Guiana Shield. It is further postulated that dispersals are a more recent phenomena beginning in the Pliocene when many species expanding their ranges in South America. Furthermore, colonization of Central America is predicted to have occurred after the Panamanian land connection (except for *Balantiopteryx*), and emballonurid bats participated in the Great American Biotic Interchange but only as northern invaders.

Preliminary Assessment of Bat Conservation in Guyana
Burton K. Lim; Royal Ontario Museum, Toronto, ON, Canada

Guyana is located on the north coast of South America and surrounded by Venezuela, Brazil, and Suriname. In terms of habitat, it forms the northern limits of the Amazonian rainforest, and geologically belongs to the ancient Guiana Shield. Guyana has a population of 800,000 with 90% of the people living in the cultivated belt along the eastern coast. The remainder of the country is sparsely populated and composed primarily of tropical rainforest with two major patches of savanna. About 80% of the natural habitat is intact with the primary environmental concerns being deforestation by timber companies and water pollutants from mining operations concentrated along a band south of the coast. There are 122 species of bats documented from Guyana, which comprises over half the mammalian diversity in the country. However, 20% of this bat diversity has been recently documented in only the past 10 years because of renewed interest in biodiversity studies. Ten bat species are on IUCN Red List of Threatened Species.

There are no species of bats endemic to Guyana but three of six that are endemic to the Guiana Shield are found in the country. In general, no species of bats are imminently endangered in Guyana but the loss of natural habitat is the primary threat. Issues requiring immediate attention to insure a healthy bat fauna in Guyana include the full implementation of the National Protected Areas System by establishing the five proposed parks, in addition to the two currently protected areas (Kaieteur Falls and Iwokrama Forest), and the development of a graduate program in the Biology Department at the University of Guyana. In particular, bat conservation in Guyana would benefit from an advocacy group to focus interest and concerns as related to their key role in the environment as seed dispersers, pollinators, and insect consumers.

Evolutionary Patterns of Morphology and Behavior as Inferred from a Molecular Phylogeny of New World Emballonurid Bats (Tribe Diclidurini)

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A molecular phylogeny of New World emballonurid bats based on parsimony and Bayesian analyses of loci from the three nuclear genetic transmission pathways in mammals (autosomal, *X*, and *Y* chromosomes) is well supported and independently corroborated by each gene tree. This is in contrast to a single most parsimonious but poorly supported tree based on morphological data, which has only one intergeneric or higher relationship shared with the molecular phylogeny. Combining the morphological and molecular partitions result in a topology similar to the molecular tree suggesting a high degree of homoplasy and low phylogenetic signal in the morphological data set. Behavioral data are largely incomplete and produce a poorly resolved tree. Therefore, patterns of evolution in morphology and behavior are investigated by using the robust molecular tree as a phylogenetic framework. Character optimization of dorsal fur appearance and preferred roosting sites map consistently and are correlated on the phylogeny. There is an association of bats with two dorsal stripes (*Rhynchonycteris* and *Saccopteryx*) roosting on the exposed surface of tree trunks, and gray or white bats (*Cyttarops* and *Diclidurus*) roosting under exposed leaves at the tops of palm trees. In contrast, the ancestral states for Old and New World emballonurids are uniform brown or black, and they roost in sheltered roosts such as caves and tree hollows. Emballonuridae is the only family of bats that has a sac-like structure in the wing propatagium, which is found in four New World genera. Mapping the wing sac character onto the phylogeny indicates that they evolved in parallel within the two subtribes (Diclidurina and Saccopterina). However, the hard polytomy at the base of Diclidurina in all gene trees indicates a rapid diversification, which further suggests that wing sacs arose independently within each genus and that there is a phylogenetic predisposition for this structure.

Rabies and Bat Conservation in Europe

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Despite two fatal human cases of bat rabies in the former Soviet Union in 1977 (Ukraine) and 1985 (Russia), the occurrence of rabies in European bats was regarded as unimportant and not a potential danger for public health until 1985. However, since the autumn of 1985, when a woman in Denmark was bitten by a rabies-positive serotine bat, *Eptesicus serotinus*, and a bat scientist in Finland died from rabies, the interest to test bats for rabies started in several countries. Bat rabies became a new phenomenon for many public health authorities and rabies researchers in Europe.

But bat rabies also became a new problem in the world of bat conservation. Bats are legally protected in most European countries, and some international treaties and the national nature conservation legislations prohibit the deliberate capture and killing of bats except under a permit from competent authorities. However, bat rabies research is necessary to gain an insight whether bat rabies is a real problem for public health and whether bat conservation is conflicting with public health on some occasions. Therefore, it is important to know the prevalence and incidence of rabies in which bat species. Passive surveillance of bat rabies in grounded bats can give information about such prevalence but additional active surveillance is required to identify the real incidence of rabies in particular species in natural situations. Some bat species are dwelling in houses and other buildings where people live and work. The serotine bat, the main carrier of bat rabies in Europe, is such a building-dwelling species. This species generally roosts well hidden in wall cavities, eaves, or other inaccessible places for men and pets, and by accident occasionally comes into rooms. Therefore, they are seldom in direct contact with humans. The conservation of building-dwelling species depends to a large extent on the tolerance of tenants and other users of buildings. The knowledge about the occurrence of bat rabies, the prevalence of rabies in bat species, and the possible risk for public and animal health is also important for bat conservationists to improve public awareness for bat conservation in conjunction with public health. There should be, therefore, a good co-operation between bat conservationists and rabies research and public health bodies.

Functional Wing Morphology in Phyllostomid Bats and Its Relation to Feeding Habits, Foraging Strategies, and Forest Types Using Relative Warp Analysis

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Wing morphology places energetic and mechanical limitations on where and how a bat forages efficiently. Wing shape determines generation of thrust and maneuverability whereas size (wing area and wingspan) determines lifting capacity. Consequently, differences in wing morphology are expected to reflect differences in flight performance and foraging behavior. We studied wing shape of 41 species of phyllostomid bats. We took three digital pictures of the right wing of each individual from every species captured and measured 11 aerodynamic parameters: arm and hand wing length, arm and hand wing area, wingspan, total wing area, aspect ratio, wing loading, wing length and area ratio, and wing tip shape. We subsequently digitalized 19 homologous landmarks on the wing pictures in order to perform a Relative Warp Analysis. We found statistically significant differences in several aerodynamic parameters depending on: 1) size (frugivores); 2) mobility (nectarivores: migratory or resident species); 3) foraging strategy (animalivores: perch hunting, continuous flight, and mixed strategy); and 4) forest type (dry forest versus rainforest). The anatomical structures mostly involved in the differences of wing shape in phyllostomid bats were the phalanges of the 5th and the 4th digit and several joints of the arm and hand wing. Differences in wing shape between phyllostomid bats showed a tight association with ecological factors. Most unexpectedly, we found distinct variability in wing shape within six species of bats depending on habitat type. Individuals from bat populations in the rather obstacle-rich rainforests were characterized by significantly larger wing areas than those from the more open dry forests. In contrast, bat populations from dry forests revealed higher aspect ratio, wing loading, and wing tip index than bat populations from rainforest

habitats. These differences in wing shape in association to forest type were mostly associated with an area reduction of the arm wing and the uropatagium.

Habitat Quality Effects on Rafinesque's Big-eared Bat Roost Site Use and Selection

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Knowledge of species' habitat requirements is necessary for effective conservation and management. Studies to obtain this information are often conducted in optimal habitat or in the center of a species range. However, information on the full range of variation of habitat use are required to develop short-term conservation strategies as well as long-term restoration plans. We studied roost site use and selection of Rafinesque's big-eared bats (*Corynorhinus rafinesquii*), a species of special concern, in two sites in the Upper Coastal Plain of South Carolina representing diverse habitat conditions and land use histories. The Savannah River Site (SRS) has a 200-year history of disturbance from agriculture and forestry whereas the Congaree National Park (CNP) contains the largest expanse of old-growth bottomland hardwood forest in the U.S. We located roost trees with radiotelemetry and tree searches at both sites. Species, diameter at breast height (dbh), tree height, decomposition state, % bark, and number of cavities were recorded for each roost at both sites and for random trees at SRS. Although tupelo trees (*Nyssa* spp.) were selected over other species at SRS, they only represented 43% of roost trees. Other species used were oaks (20%), sweetgum (20%), and other (17%). In contrast, 92% of roosts at CNP were in tupelos. Diameters of trees used at SRS (71.7 ± 14.3 cm) were significantly larger than random trees but were significantly smaller than trees used at CNP (111.7 ± 26.5 cm). Basal cavities and upper bole cavities were used at both sites. However, upper bole cavities at CNP were large cavities used by a maternity colony whereas most of the upper bole cavities used at SRS were small woodpecker holes used by solitary males. Our results suggest that roost site use and selection of Rafinesque's big-eared bats varies with habitat quality and availability of resources.

Bat Houses Can Attract Bats to Central Valley Farms

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In an 8-year study from 1996 to 2004, we evaluated 186 bat houses intended for use by bats in rural areas of California's Central Valley. The results of our study showed that the use of houses by bats depended mainly on the location of the houses. Colonies of bats (generally mothers and their young) showed preference for houses that were mounted on structures such as buildings, exposed to shade or morning sun, and that were within a quarter mile of water. In contrast, individual bats (generally males and non-reproductive females) were less selective in where they roosted. Bat house occupancy was not affected by the size, color, or height of the houses for either colonies or individual bats. The overall bat house occupancy rate in our study was 76% (48% for colonies and 28% for individuals). Mexican free-tailed bats and *Myotis* spp. bats were most often found using the houses, with the occasional sightings of pallid and big brown bats. Bat colonies occupied most houses within the first two years of placement.

Comparison of Three Bat Communities in the Mixteca Poblana, Mexico

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The aims of this work were to evaluate three bat communities in the Mixteca Poblana, Mexico. Chiroptera communities were characterized and compared in each site, and diversity, abundance, trophic structure, and similarity were described, as well as establishing the association between diversity and some habitat variables. The data obtained show that the shared species in the three communities were *Macrotus waterhousii*, *Glossophaga soricina*, and *Sturnira lilium*. The Rancho El Salado community shows the highest richness (14), the highest diversity (H' = 2.0), but the lowest abundance, unlike Mitepec. Regarding community structure in the three sites, five trophic groups were established and three size intervals; the guilds with highest richness are aerial insectivores and generalist frugivores, representing each 2.72% of total species richness. The most similar communities are Mitepec and Rancho El Salado with a Simpson Faunistic Similarity Index of 88.9% upon sharing eight species. Beyond showing similar conditions, they also have a more developed understory and a relatively lower disturbance level than the other locality. Overall the three localities have a rough landscape, with a very steep dry season, high disturbance level, and high and extended cattle grazing, which is reflected in the abundance of hematophagous species. Based on these results, it is necessary to establish conservation policies that allow us to maintain forested areas in the Mixteca with its associated bat faunas.

Diet of Mexican Free-tailed Bat in Three Big Mexican Colonies

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Studies in south-central United States have demonstrated that the seasonal moth component in the diet of the Mexican free-tailed bat (*Tadarida brasiliensis mexicana*) is closely correlated to patterns of emergence, migration, and availability of adult noctuid moth populations, which are also the major crop pests in that region. In Mexico, nightly timing and dates of emergence of this corn pest coincides with the spatio-temporal distribution of *T. b. mexicana*, suggesting that the referred bat-pest link extends to the complete distribution of this subspecies. Three large colonies (over one million individuals each) at La Boca Cave, Santiago, Nuevo Leon, El Salitre Cave, Meztitlan, Hidalgo, and San Francisco Cave, La Trinitaria, Chiapas were visited monthly in a year-round sampling. Diet composition was determined by fecal analysis. Fifteen orders and thirty-three insect families were identified. Major items by volume are represented by the orders: Lepidoptera (63%), Coleoptera (20%), Hemiptera (10%), Hymenoptera (2%), Diptera (1%), and Neuroptera (1%). The volume of lepidopterans consumed dominates dietary composition: as the moth volume consumed increases, the variety of other items found in the diet is reduced. The results are analyzed in the context of agricultural practices in the region, and the periods of seasonal emergence of noctuid moth pests. The moment in which lepidopteran volume reaches its highest values coincides with the literature describing emergence peaks of corn earworms (*Helicoverpa* zea) during summer months in the north, and with the fall armyworm (*Spodoptera frugiperda*) in the south. These results suggest that feeding by *T. b. mexicana* on these two important corn pests in Mexico is a possible natural pest control.

Systematics of Bats of the Genus *Molossus* (Chiroptera: Molossidae) Based on Morphometric and Morphological Characters

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Bats of the genus *Molossus* occur in the Neotropics from Sinaloa and Tamaulipas in Mexico to Cordoba and Santa Fe provinces in Argentina. Variation within the genus has been examined by a number of authors, but all available publications deal with only part of the genus distribution. As a result, more than 40 available names exist for these populations, and the number of species accepted varies from author to author. The objective of this research was to determine the number of recognizable morphological units based on the examination of over 1,500 museum specimens from throughout the genus distribution. External as well as none morphometric characters were evaluated. We were able to delimit nine morphological units *M. coibensis, M. aztecus, M. molossus, M. molossus* from the Lesser Antilles, *M. currentium, M. rufus, M. pretiosus, M. sinaloae,* and an undescribed form closely allied to *M. sinaloae. M. aztecus,* previously considered as restricted to Mexico and Central America, occurs as far south as SW Brazil. The distributional range of *M. currentium* in South America is extended to include the Amazon Basin and SW Bolivia. *M. coibensis* occurs in Panama and N South America. Populations from the Lesser Antilles, formerly assigned to *M. molossus,* are more similar to *M. coibensis,* although the taxonomic status of these populations cannot be clarified based on morphological evidence only.

How Do Ectoparasitic Nycteribiids Locate Their Bat Hosts

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Nycteribiid flies (Diptera: Nycteribiidae) are widespread hematophagous ectoparasites exclusively associated with bats. Although they seldom leave their bat hosts, females have to do so to deposit prepupa on the walls of the roosts, and the young emerge on them. It is, therefore, important for nycteribiids to have mechanisms to efficiently locate bats. In this study, we determined, under laboratory conditions, if nycteribiids are able to locate a bat at a distance, and the mechanisms involved in this process. In addition, we tested whether these parasites are able to discriminate between their primary hosts and other bat species. As models we used two nycteribiids (*Penicillidia conspicua* and *Penicillidia dufourii*) and their primary bat hosts (*Miniopterus schreibersii* and *Myotis myotis,* respectively). Experiments demonstrated that both nycteribiid species are able to locate bats at a distance. We studied four types of sensory cues that could be involved in such host location: vibration, body odors, heat, and carbon dioxide. We did not find any evidence that nycteribiids use either vibrations or odors as location cues. In contrast, they responded positively to the presence of carbon dioxide or heat, consistently moving towards their sources. Additionally, the combination of heat and carbon dioxide appeared to have a synergistic effect, triggering a stronger attractive response from nycteribiids. In our experiments, both *P. conspicua* and *P. dufourii* were able to locate bats, but incapable of discriminating between their specific hosts and another bat species from a distance. However, when in direct contact with the body of both bat species, they easily identified their specific hosts. In conclusion, our results suggest that nycteribiids rely on heat and carbon dioxide to locate nearby bats within roosts. However, these cues are not sufficiently specific to allow

discrimination between potential host species. Only when in physical contact with bats can nycteribiids recognize their primary hosts.

Is the Ectoparasitic Community of the Bent-winged Bat (*Miniopterus schreibersii*) Structured?

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The bent-winged bat (*Miniopterus schreibersii)* is a colonial cave dwelling species that hosts a diverse community of hematophagous ectoparasites. In general, parasite communities are considered unstructured assemblages of species, as a result of the lack of interactions between them. However, some studies demonstrated that interactions between parasitic species can occur, leading to structured communities. We used null model analysis to study the structure of the ectoparasite community of *M. schreibersii* and identify potential interactions between its parasites. We searched 869 *M. schreibersii* and found five hematophagous ectoparasite species regularly occurring on them: three nycteribiids (*Nycteribia schmidlii, Penicillidia conspicua,* and *Penicillidia dufourii*), one wing mite (*Spinturnix psi*), and one soft tick (*Ixodes ixodes*). We found the same parasite species along the yearly cycle, but their abundances varied among seasons, and depended on the sex, age, and reproductive status of the host. Random co-occurrence patterns were observed during most of the yearly cycle, suggesting that this parasite community is in general, unstructured. However, we detected a non-random pattern during the pregnancy season of the host, with parasite species co-occurring on pregnant females much less than expected by chance. An analysis of parasite species pairs suggests that the observed structure is a consequence of negative interactions between the three nycteribiid species. In conclusion, there is little interaction between hematophagous parasites throughout the yearly cycle, even in the case of the three nycteribiids that live exclusively on the fur of the host. However, a negative interaction between these nycteribiids seems to occur on pregnant females. This may be a consequence of the observed increase in the overall population of the nycteribiid species on these animals.

Identification of a New Variant of Rabies Associated with Chiropteran Host in Mexico and Its American Context

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The genus *Lyssavirus* within the family Rhabdoviridae is subdivided into seven genotypes composed of classical rabies (genotype 1) and rabies related viruses (genotypes 2–7). On the American continent, only rabies had been identified until now. The first description of rabies dates from the 23rd century B.C. in Mesopotamia. Over the centuries, this encephalitis has caused millions of human and animal deaths. Today, rabies is still recognized as one of the ten main infectious diseases responsible for mortality worldwide. Although dogs are still the main rabies reservoir in many Latin American countries, sylvatic rabies (including cases of spill-over of bat strains into livestock and humans) is increasing in Mexico, where extensive urban rabies control programs have been highly effective. To improve knowledge of these epidemiological trends, some Mexican rabies virus isolates from various host species have been characterized. Phylogenetic analysis at the viral P locus identified distinct viral strains associated with terrestrial reservoirs (dogs, skunks, and foxes/bobcats) as well as a variant associated with the insectivorous bat, *Tadarida brasiliensis*, which is consistent with prior reports. Of the two distinct clades of viruses associated with the vampire bat reservoir, one comprised just four specimens and formed an outlying group to all other vampire bat rabies isolates including those from South America and the Caribbean, a finding consistent with the early emergence of the vampire bat reservoir in Mexico. Antigenic variation of the vampire bat specimens did not correlate with the main genetic groupings; moreover complete N gene sequence analysis of selected specimens indicated limited variation within the encoded nucleoprotein that could form the basis of antigenic variation. A new viral variant of rabies virus—not previously identified in North America but probably circulates in insectivorous bats—was identified in a cat.

Long-term Reuse of Tree Roosts by European Vespertilionid Bats

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Only several studies analyzed long-term patterns of reuse of tree cavities by bats; however, all of them were concerned with North American bats. Here we report, for the first time in Europe, on long term-reuse of tree holes by two dendrophilous bat species, Daubenton's bat (*Myotis daubentonii*) and Noctule (*Nyctalus noctula*). Between 1968 and 2007, we found 77 occupied tree holes (excavated mostly by woodpeckers) in a single study area in Czech Republic. Most of these cavities were inspected for the repeated presence of bats in several consecutive years by several methods, including direct captures (more than 330 capture events, ca. 2,900 captured bats), observations of emerging bats, or by audio-visual checks during afternoon hours when bat colonies emit typical vocalization (over 130 checks). Although more than half of all tree cavities were occupied for few seasons, a significant number of these cavities were repeatedly reused for five to ten years. The longest time period for which particular tree hollows were used were 11 and even 16 years for Daubenton's and noctule bats, respectively. While 16 tree cavities (20.8%) were occupied solely by Daubenton's bats, 32 cavities (41.6%) were occupied by noctules. Another 29 tree cavities (37.6 %) were occupied by both species, either in separate periods or even simultaneously (mixed colonies). Tree holes that were occupied by both species were reused for significantly more seasons regardless of tree species. In spite of the fact that woodpeckers mostly excavate new hollows for each breeding season, we observed that they prevent most of the old hollow entrances against overgrowth by wooden callus and thus keep these hollows accessible for bats. Based on these observations, we assume that woodpeckers may have been one of the most important "factors" that provide a substantial part of suitable roosting opportunities for some European forest bats.

The Rapid Decline and Imminent Extinction of the Christmas Island Pipistrelle *Pipistrellus murrayi*

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The Christmas Island Pipistrelle *Pipistrellus murrayi* is endemic to Christmas Island, Indian Ocean. Its distribution and abundance has declined dramatically in recent years. It was widespread and common in the mid-1980s, but by the mid-1990s there had been a marked reduction in abundance and a westward range contraction. This decline has continued at an alarming rate and the species is now confined to the far west of the island, no longer occurring across more than 80% of its former range. Based on repeated detector sampling at fixed sites, there has been a decline in abundance of approximately 90% since 1994. This suggests that, if the current rate of decline continues, this species could be extinct by 2008. The cause of this rapid decline is unknown. A number of introduced species may prey on or disturb bats while within their roosts, e.g., Common Wolf Snake *Lycodon aulicus capucinus*, Feral Cat *Felis catus*, Black Rat *Rattus rattus*, and Giant Centipede *Scolapendra morsitans*. Although not considered the primary cause of decline, the recent explosion of Yellow Crazy Ants *Anoplolepis gracilipes* is likely to have exacerbated the situation. It is also possible that some form of disease may be contributing to the decline, and to investigate this, biological samples were collected in December 2005. We trapped 52 individuals at this time, with the majority of females (82%) breeding. Seven maternity roosts were located under loose bark on dead trees. Maternity colonies contained 20–50 individuals. These investigations are continuing in an attempt to avert the imminent extinction of Christmas Island's only microbat.

Microbats in Changing Cotton Production Landscapes: A Case Study from the Namoi River in New South Wales, Australia

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This study investigated the links between microbats, cotton production, and native vegetation across three cotton production properties (56 km^2) adjacent to the Namoi River between Narrabri and Wee Waa on the northwest plains of NSW, Australia. Three landscape surveys conducted during the 2003/04 cotton-growing season recorded microbat ultrasound echolocation. Calls were recorded seasonally for 20 minutes between civil twilight or sunset and midnight at 64 sites. Sites were identified through a stepwise random sampling design, proportionally representing the seven native vegetation and three intensive farming landscape elements. A limited capture survey was conducted in spring 2003. A microbat assemblage of between 14 and 17 species was identified, three species in many regions listed as vulnerable. Captured bats included three lactating females. The species were grouped in guilds according to the ultrasound frequencies used and relationships to insect hearing. The study suggested species in the guild utilizing the lower frequencies audible by insects have adapted foraging patterns to incorporate cotton fields. These species recorded the highest call abundance and the most extensive spatial distribution across all landscape elements and all seasons. A comparison of activity over fields of conventional and two-gene Bollgard II™ cotton varieties suggested reduced activity over GM cotton. The guilds of species utilizing foraging patterns below the canopy or within understory vegetation recorded the lowest presence across the whole landscape, particularly in summer. The highest species richness was recorded in spring for *Eucalyptus camaldulensis* open woodlands (14), and in autumn for *Eucalyptus populnea* (13) and mixed vegetation remnants (13). Identified activity over cotton fields suggests microbats contributed to reductions in cotton pest moth (*Helicoverpa* spp.) populations by both direct predation and interruptions to reproductive activities resultant from avoidance behavior. Contributions to pest management and microbat tree-hollow roost requirements could provide economic and environmental incentives for improved remnant native vegetation management.

The Role of Cenotes in Conserving Bat Assemblages in the Yucatan, Mexico
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Cenotes (from the Mayan word *dzonot*) are water sinkholes formed by the dissolution of limestone. In the Yucatan Peninsula, they are the main water sources for humans and animal communities. Our project investigated the importance of cenotes for bats by comparing the community structure between forest and pastureland, with and without cenotes, in order to test the hypothesis that species composition, diversity, and abundance differs significantly between sites and seasons. Five ground mist nets, one canopy mist net, and one harp trap were set at each site. Insectivorous species were also monitored with a Pettersson D980 bat detector. After 96 nights of work we caught 2,819 bats and analyzed 2,280 recorded minutes of calls from free-flying bats from 6 families and 37 species. *Artibeus jamaicensis* and *Peropteryx macrotis* were the most abundant species with capture and acoustical sampling, respectively. Mist nets were highly effective at capturing phyllostomids whereas harp traps were effective at sampling mormoopids that forage close to the ground. However, 11 species that detect or fly at higher altitudes (e.g., *Molossus sinaloae, Nyctinomops laticaudatus*), above the height of nets and harp traps, were recorded exclusively with acoustical sampling. Our results demonstrated a higher bat diversity and abundance at habitats with cenotes than the same habitats without cenotes. In deforested landscape such as pastureland, these water bodies and their surrounding vegetation are particularly important, providing feeding and roosting resources for bat species of different guilds. Protection of cenotes is vital not only for conserving bats but also because these habitats represent potential seed sources for the regeneration of the deciduous forest of northern Yucatan in which bats play a key role as pollinators and seed dispersers.

Evaluation of the Conservation Status of *Artibeus fraterculus* in Ecuador: Use of Niche Modeling to Estimate Species' Geographic Distribution
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The knowledge of geographic distribution of a species is critical to conservation assessments. The fruit-eating bat, *Artibeus fraterculus*, is restricted to the dry regions of the southwest of Ecuador to central western Peru. The conservation status of *A. fraterculus* has changed drastically in the last six years. According to the IUCN red list (2006), this fruit-eating bat is considered vulnerable but its status has been evaluated as endangered to data deficient (insufficient to rank) by Tirira (2001). One of the most important potential threats to its populations is that during the last 30 years, the dry forest of the semi-arid regions particularly of Ecuador has been drastically reduced by deforestation, resulting in a general decrease of the biodiversity of this ecosystem. The severe habitat loss produced by agriculture has restricted the range of distribution of several species. Nevertheless, recent reports suggest that this species is still very abundant and easy to collect. Here we employed the maximum entropy algorithm (Maxent) using occurrence records and environmental data to predict the potential distribution of *A. fraterculus* in Ecuador. Based on the areas of suitable environmental conditions we evaluated the current status of the populations and their conservation conditions. Maxent model indicates the presence of *A. fraterculus* through tropical and subtropical regions of western Ecuador and a continuous distribution of populations through the dry forest of the Tumbesian ecoregion. Regions of suitable environmental requirements include the current intervened areas and native forest remnants. Although suitable environments for *A. fraterculus* are well extended throughout the studied region, this research represents a baseline that can be used to evaluate other species with more specific habitat ecological requirements. It is important to consider the impact of habitat fragmentation to elaborate successful conservation strategies.

Activity Patterns of Nine Phyllostomid Bat Species in a Fragment of the Atlantic Forest in Southeastern Brazil

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Seasonal, monthly, and hourly activity patterns of nine bat species were studied based on their capture rates at the Reserva Particular do Patrimônio Natural Feliciano Miguel Abdala (RPPN-FMA), Caratinga, Minas Gerais state, southeastern Brazil. A total of 310 individuals of 9 species were caught, as follows: *Artibeus obscurus* (n = 9), *A. lituratus* (n = 31), *A. fimbriatus* (n = 8), *C. perspicillata* (n = 200), *S. lilium* (n = 32), *P. lineatus* (n = 5), *A. caudifer* (n = 10), *C. minor* (n = 10), and *G. soricina* (n = 5). The frugivorous and nectarivorous bat species have their activity closely related to the availability of food. Although we found a significant difference in hourly activity patterns of *C. perspicillata* and *S. lilium*, and *C. perspicillata* and *P. lineatus*, this cannot be invoked as a resource partitioning strategy, since the fruits taken in the beginning of the night cannot be replaced by others in a short period of time. The idea of reduction in resource competition, due to hourly activity divergence, can only be acceptable for insectivorous and nectarivorous bat species, which explore quickly renewable resources. Further studies on frugivores-plants interactions should be conducted to assess the long-term consequences for the whole system at the RPPN-MFA.

How Do Management Practices on Cork-Oaklands Influence Bat Activity?

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Bat conservation is strongly linked to land management actions. “Montado” or “dehesa” is an extensive land use system that combines cork oak and stone oak forestry with sheep and cattle raising, and cereal crops. In the Mediterranean region, “montado” is one of the most representative habitats with high economic importance. Using ultra-sound detectors we aimed 1) to study bat activity over different habitats, and 2) within the cork oak “montado” habitat to assess the impacts of the specific management actions on bat populations. We monitored bat activity on 40 sampling stations in each month, from May to September 2004, and collected data on climate, landscape variables, and management practices. Our results indicate that considering the wider landscape bat activity and foraging were higher in areas with higher tree density. Bats used, in decreasing order, small urban areas, riparian habitats, cork oaklands, and intensive farmed areas. On the 19 stations located in “montado,” bat activity was negatively influenced by percentage of undergrowth clearance. Time since the last cork extraction also influences bat activity. Stands where cork extraction occurred in 2004 were less used, with bat activity increasing with time since tree debarking. Current trends of intensification of the land management of “montado” seem to have a strong impact on bat activity, and therefore on bat

populations. Conservation actions in cork oaklands should include the management of the undergrowth clearing, encouraging the maintenance of areas of scrub.

Bat-Plant Frugivory Networks: Organization and Fragility to Extinction

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The network approach has stimulated new insights in the study of ecological interactions. Bats are an excellent study model as they have a high dietary diversity. In the present study we tested the hypothesis that bat-plant frugivory networks show a nested structure and asymmetrical dependencies, as usually observed among free-living mutualists. We also investigated if the extinction of bats and plants considered as 'keystone species' in the literature leads to greater changes in network structure than the extinction of other species. Our analysis comprised eight published datasets from different Neotropical localities. First, we described their topology and asymmetry of dependence. Then we simulated the removal of a bat or a plant species and searched for shifts in two network properties: nestedness and number of species, testing for differences in structural shifts among keystone and other species. As expected, structural patterns were similar to other mutualistic systems. All networks exhibited nestedness, in which there is a core of species with many interactions, and species with few interactions are connected to this core. There was also a high asymmetry in the dependencies of species pairs, i.e., when a species mainly relies on another species as a food source (plant) or disperser (bat), that other species does not rely on the first one. The removal of keystone and other species showed both similar weak effects on network structure. Although caution is required due the assumptions of our simulations, theoretical studies suggest that nestedness and asymmetry, as observed in the present networks, are likely to increase the resilience and long-term stability of ecological communities, indicating that bat-fruit interactive systems may be very resistant to extinctions.

Late Pleistocene Morphological Variation of the Australian Ghost Bat, *Macroderma gigas* (Microchiroptera: Megadermatidae) at Mt. Etna, Australia

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New late Pleistocene faunal assemblages located at Mt. Etna, central eastern Queensland, and spanning from 500,000 years old to about 10,000 years old, have allowed the study of morphological variation through time of the Australian ghost bat, *Macroderma gigas*. Late Pleistocene *M. gigas* from Mt. Etna differed significantly from the modern species from the same locality in having smaller cranial and dental characters, such as the zygomatic region, anterior nose-shield width, palatal length, toothrow, premolars, and molars, thereby giving the bat a more robust and stockier appearance of the face. Late Pleistocene populations were also found to share more morphological resemblance with modern populations from the Kimberley region, northwestern Western Australia, than they did with populations from elsewhere in Australia, especially including the modern population at Mt. Etna. Whether the modern colony at Mt. Etna is part of a continuous lineage since the late Pleistocene or an offshoot of northern populations

remains unclear. Regardless, the morphological changes are likely to be an adaptive response to changes in prey availability as a result of increased aridity.

Post-natal Growth of the Free-ranging Old World Leaf-nosed Bat, *Hipposideros turpis*

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Studies of the post-natal growth of free-ranging bats are few and are biased towards vespertilionid bats and temperate species. I have studied the post-natal growth of the Old World leaf-nosed bat *Hipposideros turpis*, which is an endangered subtropical species. For over 15 years, I have banded and measured the growth of individual bats from the newborn period (with the umbilical cord) up to the age of 2–3 months. The rate of recapture of banded young decreased with age, although this number was increased slightly by using colored bands. The average forearm length of newborn infants (numerical value derived for more than 1,000 individuals) was 30.93 ± 2.44 mm, and the average body mass was 8.00 ± 0.86 g. Over 13 years, the average growth curve of the bats differed. The yearly change of body mass was greater than that of the forearm. This indicates that wing size needs to be stable to facilitate the aerial life of the bat. The yearly differences in the slopes and elevations of the body mass growth curves appear to relate to yearly differences in climate (temperature, rainfall) and the growth stage of the infant bat.

***Harpiocephalus harpia* and *H. mordax*: Two Species of Hairy-winged Bats or the Story of Misalliance?**

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Harpiocephalus mordax, or the greater hairy-winged bat, was once considered a subspecies of *H. harpia*, but for the past 20 years it has been widely accepted that it should be regarded as a distinct species. However, there is one remarkable circumstance: all known specimens are females. Das, who did not recognize *H. mordax* as a species, revealed a wide range of individual variation in size and pelage color among Indian specimens, as well as sexual dimorphism. Nevertheless, Corbet and Hill stated later that a small series of two males and three females of *H. harpia* from Java, deposited at the Natural History Museum (London, UK), demonstrates a lesser degree of dimorphism, therefore being the only justification for the species distinctiveness of *H. mordax*. However, the recent record of both “forms” from Cambodia, as well as other cases of repeated syntopic occurrence of male *H. harpia* and female *H. mordax*, prompted me to study this issue in more detail. As a result, the specific distinctiveness of *H. mordax* was rejected based on the combined morphological and molecular genetic datasets: this taxon should be regarded as a junior synonym of *H. harpia*.

Physiological Adaptation of Bats and Birds to Islands: Implications for Conservation

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A general pattern in the physiological characteristics of vertebrates endemic to small, isolated oceanic islands has been emerging in the last decade. Birds and bats, the only endotherms that regularly disperse to isolated islands, generally have lower standard rates of energy expenditure than their relatives that live on large islands and continents. This reduction is accomplished both through a decrease in mass and a decrease in energy expenditure independent of body mass without affecting the capacity for flight. The repeated evolution of a flightless condition in birds endemic to oceanic islands, another means of reducing energy expenditure, has not occurred in bats, possibly because they have food habits that are not compatible with a flightless condition. Many of the most distinctive island endemics, including some bats and most flightless birds, became extinct through the human conversion of islands into mini-continents by the cutting of forests, hunting, and the introduction of alien species, including predators and disease vectors, a process that continues. Furthermore, bats of the genus *Pteropus*, most of which are island endemics, cannot withstand a shortage of food for more than a few days, potentially a problem during cyclonic and El Niño/La Niña events. A small resource base, unstable climate, and absence of eutherian predators may collectively permit, and even require, the evolution of low rates of metabolism and low rates of reproduction—characteristics that increase the propensity for extinction in bats endemic to islands.

The Program for Conservation of Mexican Bats: Twelve Years of Local, National, and International Conservation Efforts

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The Program for the Conservation of Mexican Bats (PCMM for its acronym in Spanish) is a collaborative bi-national initiative between México and the USA, headed by the Instituto de Ecología, National University of México with the participation of over ten additional institutions. Its primary objective is to protect bats and their habitat across México. Through a network across 22 Mexican states, the PCMM is aimed at protecting around 140 Mexican bat species, their roosts, and habitats using a three-pronged bi-national strategy: research, environmental education, and conservation actions. Research is focused on studying migration patterns and factors that affect them, ecosystem services, and conservation needs, using molecular genetics, stable carbon isotopes, and multidisciplinary approaches. We identify priority caves by colony size, role in the migration process, or severity of threats. Around these caves, we educate local inhabitants, monitor bat population sizes, and establish conservation programs and management plans for the creation of protected areas in collaboration with Mexico's Federal Government. Also, a campaign to bring basic knowledge of bats to the general public has been implemented through book stories, radio programs, TV spots, and the like. In twelve years of work, the PCMM has shown stability or recovery of bat populations in more than 20 priority caves, and 10 new protected areas will be created in the short term. We also have rediscovered a species of endemic bat that was supposed to be extinct, and are working on three additional threatened endemic species to prepare recovery programs sanctioned by the Federal Government. Only through national and international collaboration and data sharing with many institutions in both countries is this task possible. Our program is being replicated and adapted in several other countries.

Approaching Targets: Requests and Variability in Echolocating Vespertilionid Bats
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The echolocation behavior of vespertilionid bats approaching a specific target is characterized by a decrease of pulse duration and pulse interval. In aerial/trawling foragers the approach sequence ends with a distinct terminal group consisting of buzz I and buzz II. Buzz II is emitted close to the moving prey and is characterized by very short signals and pulse intervals. Buzz II is missing in gleaning bats when they approach a stationary site with prey. They emit a terminal group that is comparable to buzz I alone. The approach behavior to stationary targets (e.g., landing sites) in non-foraging situations has been poorly investigated to date. Therefore, we compared the echolocation behavior of Natterer's bats in two natural situations: approaching a large stationary landing site or a small moving mealworm. We trained the bats to land on a stationary vertical platform, and to catch a tethered mealworm moving in the air. For the 3D reconstruction of the bat's trajectory, we used two video cameras that were synchronized with sound recording equipment. When closing in on the stationary landing site and on the moving mealworm, *Myotis nattereri* decreased pulse duration and pulse interval. A distinct buzz II was always present when bats caught the mealworms. When bats approached the landing site they emitted either a buzz I alone or sometimes also added a shorter buzz II. We observed a similar echolocation behavior in landing *Myotis myotis*. They added a buzz II when they changed flight direction in the last moment before landing. The time between beginning of buzz II and contact with the target was shorter than the reaction time of the bats. Therefore, the information collected with buzz II does not guide the bat to the target.

Bat-Plant Frugivory Networks: Trophic Subgroups among Fruit-eating Bats
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Different species play similar ecological roles in communities, and to study this redundancy is important in order to understand the organization and resilience of natural systems. In this context, bats are interesting study models, because they are very diverse, abundant, and interact with several kinds of organisms, and thus provide good opportunities for testing hypotheses. Previous studies have pointed out that bat communities are structured in 'guilds,' according to preferred food, main habitat, and foraging behavior. Some other studies suggested that frugivorous bats from different genera prefer different plant families. Thus, in the present study we aimed to test if there are subgroups among fruit-eating bats, according to the concept of cohesive subgroups derived from a complex network approach. We analyzed data from seven published studies that described plant-bat interactions in different Neotropical localities. Only three of them presented a significant but low degree of diet overlap in diet, whereas the remaining three networks were organized in clusters of species that share similar resources. In all of them, most high values of niche overlap were observed among species of the same subfamily. Our results suggest that although there is some degree of preference mainly related to phylogeny, different frugivorous bats in a local community share food items intensively. Therefore, because formation of subgroups is not strong among frugivorous bats, we conclude that this group presents a high ecological redundancy. Among possible consequences of this kind of organization, we suggest that the maintenance of seed dispersal services delivered by bats in Neotropical systems is robust to the extinction of some species.

The Last of the Mohicans: Would Neotropical Bats Maintain Seed Dispersal Services for Large-seeded Plants in Defaunated Landscapes?

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Many tropical tree species have fruits adapted for dispersal by large bodied vertebrates such as guans, monkeys, and terrestrial ungulates or rodents. However, dispersal services for these plant species may be disrupted in forest fragments once large vertebrates are more susceptible to local extinction after fragmentation. Frugivorous bats are known to persist relatively well in fragmented landscapes but their role as dispersers of large seeds is poorly known probably due to a bias in the studies on defecated small seeds during bat captures. In this study we used the seed bank collected under leaf tents most used by the bat *Artibeus watsoni* to test the hypothesis that bats may be able to disperse large-seeded plants. In the region of the Sarapiquí basin, Costa Rica, we sampled the seed bank under 70 bat tents (42 in 2 continuous forest sites and 28 in 3 forest fragments). For each tent plot we also sampled four control plots beside tents. Our results showed that this species of fruit bat can disperse as many as 34 species (27 in continuous forest and 19 in fragments) of large-seeded plant species (from 8–41 mm) comprehending trees, shrubs, lianas, and palms. The seed bank under bat tents is denser and has more species per area than samples out of tents in both continuous forest and fragments. Our results suggest that bats may play an important role as seed dispersers in defaunated landscapes since a relatively small fruit bat species can disperse many large seeds and generate a more diverse seed bank than the random seed rain in both continuous forest and fragments.

The National Bat Monitoring Programme in the UK: Delivering Trends for Bat Populations and Assessing Future Priorities

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The Bat Conservation Trust (BCT) has been running the National Bat Monitoring Programme (NBMP) in the UK since 1996. It is the longest-running multi-species monitoring program for mammals in the UK and currently produces statistically robust trends for 11 of the UK’s 17 resident bat species. The NBMP uses field surveys with bat detectors, hibernation site counts, and summer maternity colony counts to provide trend data. Trend data from the NBMP are used in the decision-making process for implementing Species Action Plans for species that have been identified as priorities in the UK Biodiversity Action Plan. Progress against targets in these plans will be monitored using future trend data. The NBMP is a model national monitoring program and the methodology has already been transferred to Romania, with other countries earmarked for future collaboration. There are also plans for a Pan-European Monitoring Program, based on NBMP protocols, for underground sites. As well as delivering national trends, the NBMP aims to deliver regional trends and ultimately to provide data on the importance of bats as indicators of environmental quality and climate change.

Environmental Education: The Work of the Bat Conservation Trust in the UK
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Public engagement and education are critical to Bat Conservation Trust's (BCT) work. BCT provides a wide range of information and tailored resources, working in various ways with the following groups:

1. General public
   - Increasing knowledge of British bats;
   - Understanding of how bats interact with urban and rural environments;
   - Awareness of the law;
   - Enabling people to get more involved with their local bat populations;
   - Training in the use of bat detectors to enable people to take part in monitoring;
   - Education of children, teachers, and young people about bats, bat conservation, and general environmental principles.
2. Batworkers
   - Training in bat surveying and monitoring;
   - Supporting people involved in bat surveying and monitoring and those involved in meeting and educating the public;
   - Enabling those working with bats to understand the law and best practice.
3. People whose jobs could impact bats or their roosts
   - Educating and raising awareness among people who may come into contact with bats professionally, e.g., arborists, ecological consultants, the construction industry, and local authority planners;
   - Increasing understanding of the law and best practice and how it may affect their work;
   - Increasing understanding of how bats interact with the built environment;
   - Encouraging them to think creatively about bat conservation, e.g., the incorporation of roosts within new buildings.
4. Researchers
   - Sharing new research and promoting clear, consistent standards for bat research to other groups;
   - Communicating outcomes of research to a wider audience, through publications and conferences.

The resources available range from posters and leaflets to articles and CDs, with delivery methods including seminars, bat walks, and training courses. The content of the educational package, too, needs careful targeting. Only by taking a broad view of education in this way can bat conservation be built on a strong base.

Material Properties of Bat Wing Bones Estimated by Cantilever Bending
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The material properties and structural anatomy of bat wing skeletons are shaped by a trade-off between adequate resistance to bending under aerodynamic loads and a need to reduce overall energetic expenditure during flapping flight. Previous work has shown that the mineral content of skeletal elements in the bat wing decreases proximodistally from 55–60% in the humerus to approximately 30% in the phalanges. In contrast to typical mammalian bone, which is ca. 70% mineral, mineralization values for bat bone suggest significantly lower stiffnesses. Moreover, bat wing bones taper substantially distally, indicating significant changes in mechanical properties along the length of each bone. We measured flexural stiffness, EI, a combination of modulus of elasticity, a material property, and second moment of area, a measure of structural geometry, in the wing bones of three specimens of *Glossophaga soricina*. We applied loads to each bone using cantilever bending, and recorded changes in bone curvature with load, testing the humerus, radius, metacarpals III, IV, and V, and the first and second phalanges of digit III. We developed a model that posits that flexural stiffness changes linearly along the bone and can be estimated using the Euler-Bernoulli bending equation. We found that the humerus and radius had the highest overall flexural stiffness (0.00156 and 0.00131 Nm^2, respectively), whereas the metacarpals were between 8% and 62% as flexurally stiff. Phalanges were least stiff, even less than 1% of the humeral and radial values. Comparison of these results to published values suggests that there is likely significant interspecific variation in the mechanical properties of wing bones. This study also documents that phalanges, and also metacarpals, radii, and even humeri, undergo bending into geometries of substantial curvature under relatively small loads likely to be similar in magnitude to those typically generated during normal flight behavior.

Climate Change and Vampire Bats: Latitudinal and Elevational Shifts in North America
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One of the most dramatic impacts of climate change is the shift in species distributions and subsequent consequences on ecosystem structure and function. Climate change affects many species either directly or indirectly via habitat shifts or resource decoupling. Mammals are no exception to this rule and current as well as future range expansions are well documented for many species including the red fox, porcupine, and collared lemmings. Studies on bats have been primarily limited to noting the impact of habitat changes on roost availability and documenting the elevational changes in species distribution. Specific studies on individual species responses are generally lacking. Here we present a model that predicts future range expansion of vampire bats, *Desmodus rotundus*, over the next 75 years. The current northern distribution limit of *Desmodus* is closely related to the winter 10ºC minimum isotherm because these bats are energetically limited at low temperatures and cannot sustain sufficient blood consumption to survive at lower temperatures. In this study we modeled the change in the 10ºC isotherm under different climate change models (CCC, ECHAM, and Hadley) and three model scenarios for the time periods of 2020, 2050, and 2080. Over the next few decades the 10ºC isotherm, and thus the distribution of *Desmodus*, is predicted to expand significantly along the east and west coasts of Mexico, Baja California as well as the southern tip and gulf coast of Texas. Disjunct areas of suitable temperature are also predicted for southern parts of Florida and Arizona. *Desmodus* range size is expected to increase by at least a third of its current Mexico range, and as it extends higher in elevation will occupy almost the entire southern and coastal regions of Mexico along with areas of Texas, and possibly other southern states like Arizona and Louisiana.

Conservation Status of Bats in Sub-Saharan Africa

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Sub-Saharan Africa covers a diverse range of biomes and associated habitats from desert to tropical forest and supports a rich bat fauna. Two hundred and sixty-seven species in ten families have been recorded from Africa and surrounding islands, including Madagascar. The Global Mammal Assessment (GMA) held in 2004 evaluated the conservation status of bat species occurring on the continent and oceanic islands (excluding Madagascar). Two hundred and nineteen species were assessed. One is extinct, 41 are threatened (Critically Endangered, Endangered, or Vulnerable), 33 are Near Threatened, 106 are Least Concern, and 38 are Data Deficient. Of the eight Critically Endangered species, five are island endemics. The large number of Data Deficient species reflects our limited knowledge of African bats. Population declines of African bat species mostly are founded on indirect evidence such as habitat destruction, and quantitative data documenting such declines are scare. A noteworthy exception is the fruit bat *Eidolon helvum* whose population in Kampala, Uganda, has declined from 250,000 to 40,000 in 40 years. Bat populations across Africa face habitat destruction, disturbance and harvesting at roost sites, poisoning, and pesticides. The taxonomy and phylogeny of many African bat genera remains in urgent need of revision. Several species not considered threatened by the Red List are likely to include cryptic species with restricted distribution ranges and hence at risk. Priority and practicable conservation actions include gap analyses (identifying deficiencies in the network of protected areas), long-term monitoring programs focusing on selected species or sites, mapping of important cave roosts, all in tandem with public awareness programs.

Predation on Bats by Feral Cats at Culebrones Cave, Puerto Rico

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We examine the predation of bats by feral cats at Culebrones Cave, Puerto Rico, West Indies. Culebrones Cave is a hot cave located in the karst region of northern Puerto Rico. The temperature gradient inside the cave sustains a multi-species assemblage of bats consisting of approximately 300,000 individuals of six species, namely: *Brachyphylla cavernarum, Erophylla sezekorni, Monophyllus redmani, Mormoops blainvillii*, *Pteronotus quadridens*, and *Pteronotus parnellii*. Feral and domestic cats are known to adversely impact native faunas in the areas where they have been introduced. This impact is even greater on islands. Even though rats are often their primary prey, cats will use alternative prey, which enables them to maintain their abundance when one prey is not available. In Puerto Rico, birds and reptiles are known to be preyed upon by cats. Although cats are commonly observed in or around bat caves in Puerto Rico, no systematic attempt has been made to evaluate their impact on bat populations. Here we report preliminary observations on predation on bats by feral cats. We made observations of the hunting strategy of cats and recorded the number of wings left as remains of these hunting bouts. Wings were identified to species. Although our preliminary data do not allow the establishment of clear patterns, it seems like bat captures are not a function of their potential prey abundance in the cave. While *Mormoops blainvillii* (11 g) and *Pteronotus quadridens* (5 g) are more commonly captured with a harp trap placed where the cats hunt, *Brachyphylla cavernarum* (50 g) and *Monophyllus redmani* (11 g) are captured in greater numbers by the cats.

Modeling Reproductive Patterns of Three Frugivorous Bats in a Naturally Fragmented Region of Northwest Yucatan Peninsula, Mexico
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In spite of their importance in the ecology and biodiversity of tropical environments, data on reproductive phenology of bats in the Mesoamerican region are still scanty, particularly for populations inhabiting naturally fragmented landscapes. In the coastal wetlands of northwest Yucatan Peninsula in Mexico, tropical rain-forest vegetation is mainly represented by naturally formed forest islands locally known as *petenes*, which harbor diverse bat assemblages. From a three and a half-year period of bat sampling in the *petenes* ecosystem, we modeled reproductive patterns for three of the best-represented frugivorous bat species in our samples: *Artibeus jamaicensis*, *A. intermedius*, and *Dermanura phaeotis*. Specifically, based on the observed number of reproductive females (pregnant or lactating) for a given month, we modeled the expected monthly abundance curves of pregnant, lactating, or post-lactating females for a standardized annual cycle. Reproductive females were recorded from March to July and September in the case of *A. jamaicensis* (n = 118) and from March to October in the case of *A. intermedius* (n = 100). Reproductive females of *D. phaeotis* (n = 121) were recorded along the year with the exception of July and September. Males of the three bat species showed evidence of reproductive activity throughout the year. We determined a seasonal bimodal polyestry reproductive pattern for *A. jamaicensis*, and a seasonal polyestry pattern for *A. intermedius* and *D. phaeotis*, respectively. Our study suggests that the reproductive patterns observed seem to be associated with food availability in the habitat-island matrix of this natural fragmented region of Mesoamerica.

In and Out of the Tropics: Genetic Variance of *Leptonycteris yerbabuenae* in Mexico
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The tropical long-nosed bat *Leptonycteris curasoae* Martínez and Villa (Phyllostomidae; Glossophaginae) is considered an endangered species, highly specialized in feeding on floral resources in arid and semi-arid environments of North America. It is considered as the most important pollinator of columnar cacti (tribe Pachycereae) as well as plants of the genus *Agave* in North America. This bat has been considered a generalized latitudinal migrant, moving throughout all of its distribution range in North America from SW United States to tropical regions of Mexico during fall, whereas during spring the animals return to their northern limit of distribution. It also has been proposed that there are resident populations of this bat in the tropics that move locally and feed upon resources produced in the tropics. Using two different techniques of molecular biology (RAPDs and mtDNA), we analyzed the genetic differences between the northern migratory population and the south-central population. Our results suggest that there are two well-differentiated populations of *L. yerbabuenae* in Mexico, one along the

Pacific Coast ranging from Sonora to Chiapas, and another distributed mainly in the south-central part of Mexico.

Bat Wing Mites of the Genus *Periglischrus* from Bats of the Genus *Monophyllus* from Islands in the Caribbean Sea

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Currently the genus *Periglischrus* has 24 nominal species associated with phyllostomid bats in the Americas. Recent morphological analysis has given rise to valid patterns that make up two principal clades of evolutionary trends. Each clade showed a very close relationship with their host bat subfamilies or tribes. Furthermore, some other idiosomal ornamentations and leg chaetotaxy patterns, were useful to define eight groups of species in both clades. The *Periglischrus* parasites from bats of the genus *Monophyllus* were obtained from the mite collection of the Bishop Museum, Hawaii. Those mites came from the Caribbean Islands of Jamaica, Hispaniola, and Guadeloupe. We have studied these mites from the hosts *Monophyllus redmani* (Jamaica and Hispaniola) and *Monophyllus plethodon* (Guadeloupe). We defined that these mites represent a new undescribed species that belongs to the *caligus*-clade and to the group *vargasi*. This group of parasites is associated with the Glossophaginae. Additionally, we used morphometric analysis to evaluate the evolutionary rate of these parasites related to both host species and island distribution. We found that about 12 characters, mainly of Pronotal region and Femora, may explain the variation observed in the samples. The cluster analysis performed by ordination data, using the Ward method for clustering, shows clearly the separation between sexes. In the females, there is a clear separation into two groups, one with specimens from Jamaica and Hispaniola that share the same host (*M. redmani)* and are geographically close, and the other with specimens from *M. plethodon* from Guadeloupe, which is the furthest locality. [Financial assistance was provided by the Dirección General de Asuntos del Personal Académico, Universidad Nacional Autónoma de México, Grant IN221906 to J.B.M-M.]

Bat Conservation Priorities for Northern Mexico

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Bats pay no heed to international borders. Many vital species travel between Mexico and the United States along the trail of migrating insects and the nectar-rich blossoms of agave and cacti. Only an international effort can conserve these border-jumping bats—and that is the goal of Bat Conservation International's Borderlands Initiative. Last year, the Initiative, undertaken with partners in Mexico, launched the first systematic field research to document the status, threats, and conservation needs of bats in six states of northern Mexico. Eighty-seven current and past bat roosts, mostly in caves, were identified and surveyed. Guano deposits and roost stains indicate these caves once supported more than 40 million bats of at least 17 species. Fewer than half of that number remain today. Six of the nineteen major roosts were empty, for a loss of some 15 million bats at just those sites. Cave-dwelling bats throughout the region are severely threatened. And many of them, including Mexican free-tailed bats (*Tadarida brasiliensis*), as well as the endangered lesser and Mexican long-nosed bats (*Leptonycteris yerbabuenae* and *L. nivalis*), spend about half of each year in the United States. Even as our research details the breadth of the problem, the Borderlands Initiative is working toward solutions. Education at all levels provides much of the foundation on which long-term conservation can be built.

Adaptive Trade-off in Corolla Shape Favors Specialization For Flowers Pollinated by Bats and Hummingbirds

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Evolution towards increased specificity in pollination systems is thought to have played a central role in the diversification of angiosperms. Theory predicts that the presence of trade-offs in adapting to different pollinator types will favor specialization, yet few studies have attempted to characterize such interactions in nature. I conducted flight cage experiments with bats, hummingbirds, and artificial flowers to examine effects of corolla width on pollination. I videotaped visits to analyze pollinator behavior, and counted pollen grains transferred to stigmas. Results demonstrate that flower-pollinator fit is critical to effective pollination; wide corollas guided bat snouts better and narrow corollas guided hummingbird bills better. Poor fit resulted in variable entry angles and decreased pollen transfer. A model using these results predicts that wide corollas will be selected for when bats make more than 44% of visits and narrow corollas when they make less. Intermediate corollas are never favored (i.e., generalization is always suboptimal). This is the first study to clearly document a pollinator-mediated fitness trade-off in floral phenotype.

Roost Selection of Evening Bats (*Nycticeius humeralis*) in Southeastern Michigan

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Although common in parts of the eastern United States, the evening bat (*Nycticeius humeralis*) is rare to uncommon at the periphery of its range. There is only a single colony known in the state of Michigan, and it is the northernmost colony of evening bats on the North American continent. In 2006 and 2007, we obtained data on roost-tree selection and inter-roost movement. We mist-netted bats from May to August 2006–2007 within the floodplain of the River Raisin, Black Creek, and Bear Creek, and placed radio transmitters on adult and juvenile evening bats. We confirmed roost trees by radio-tracking daily each bat and observing evening emergence. We performed plot- and stand-level habitat assessments on confirmed roost trees. Bats roosted in cavities, crevices, and under exfoliating bark. Roost selection differed by reproductive condition; however, preliminary data indicate that the diameter-at-breast height and height do not differ significantly between roost trees with cavities, crevices, or exfoliating bark. Furthermore, diameter and height of roost trees were greater than those of random trees within the roost plot. Examining the roosting ecology of the evening bat at the periphery of their range will elucidate summer roosting habitat requirements of females during different reproductive stages.

Evolution of Patrilocal Kin Groups in the Polygynous Sac-winged Bat (*Saccopteryx bilineata*)

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In most mammals and birds dispersal is more prevalent in one sex, while a higher proportion of the other sex is faithful to its place of birth. Such sex-biased dispersal is believed to stem from inbreeding and kin competition avoidance, while the direction of the bias is assumed to depend upon a species' mating system. Many models predict that high local mate competition should induce a male-biased dispersal in species with polygynous social systems. This prediction is in line with the pattern found in the majority of mammal species including bats. The Neotropical sac-winged bat (*Saccopteryx bilineata*) is one of the rare exceptions to the general mammalian pattern, as females are known to disperse from their natal colony and males have been observed to be philopatric. We investigated the natal dispersal behavior of females and males over the course of six years in one colony containing up to 60 adult individuals and up to 12 harem groups. Dispersal was significantly female-biased with 99% of females leaving the natal colony before adulthood. We used 11 microsatellite markers to reconstruct kinship relations between the 51 males that were residents during our study period and were able to allot these into 12 patrilines. Our finding suggests that inclusive fitness benefits via facilitated settlement of sons exceed the costs arising by kin competition for resources and mates. Male natal philopatry and female breeding philopatry cause the potential for inbreeding. We propose that females disperse to avoid father-daughter inbreeding and show that female mate choice of unrelated males (by extra-harem mating) prevents inbreeding between females and their male descendants.

Seasonal Sebum Patch in the Nectar-feeding Bats *Leptonycteris curasoae* and *L. yerbabuenae* (Phyllostomidae: Glossophaginae): Phenological, Histological, and Preliminary Chemical Characterization

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As research on bat biology progresses, an increasing number of investigations indicates that many species of bats secrete a wide variety of substances, frequently associated with different forms of olfactory communication. Despite being a species-rich microchiropteran family, only a fairly limited number of studies have examined the presence of glandular scent organs and skin secretions in Phyllostomidae. In this study we characterized a seasonal phenomenon of massive sebum secretion in the Curaçaoan long-nosed bat, *Leptonycteris curasoae* in Venezuela, and also provide evidence supporting occurrence of the same phenomenon in the lesser long-nosed bat, *L. yerbabuenae*, in Mexico. We determined the phenology of the sebum patch in both countries. In addition, we conducted a histological study of the affected area, using specimens of *L. curasoae* from the Paraguaná Peninsula, Venezuela. Finally, a preliminary chemical characterization of the

sebum was performed, combining histochemical techniques with GC-MS analyses. The sebum patch was detected exclusively in male adult specimens. Individuals presenting it had a grease and odoriferous area of circular shape and variable surface covered with sebum at the level of the interscapular zone. Occurrence of the sebum patch overlapped with the mating season in Venezuela and Mexico. The following histological changes associated with occurrence of the sebum patch were observed: increase of epidermis thickness and decrease of dermis and hypodermis thickness; increase in density of sebaceous glands; increase of percentage of skin covered by sebaceous glands; increase of size of sebaceous glands previous to secretion followed by a marked decrease after secretion; and increase of the sebum volume within sebaceous glands previous to secretion. Fifteen nonpolar compounds were identified in the sebum, including fatty acids, cholestans, and cholesterol. Our results suggest that the sebum patch phenomenon described is a mechanism of olfactory communication possibly related to mating behavior in these bats.

Environmental Education in Bat Conservation

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During the last twenty years, the number of educational activities and interdisciplinary programs about bats has increased considerably, but environmental education continues to be only a marginal subject. This is reflected in the majority of publications on conservation biology of mammals, in which most of the articles deal with purely biological issues and not social aspects. This is also true regarding funded projects and previous IBR conferences. Therefore, a “Symposium on Environmental Education” was organized as part of the 14th IBRC/37th NASBR, in which some of the most significant experiences in different countries were presented and analyzed. The objectives of the Symposium were: 1) to open a space for the analysis and discussion of the social aspects of the conservation, basically about environmental education; and 2) to generate a document that serves as a tool for all of the people that work with bats, preparing educational activities for different school levels. As long as we favor the creation of more spaces for the joint work among those who directly research the biology of bats, and those who work with more subtle and unpredictable issues, the actions of the people that coexist with them, then better scientific articles will be produced, which will serve as a basis for proposing stronger conservation projects to maintain this important group of mammals. Finally, we will also provide informed documentation to outreach more interdisciplinary works.

Conservation of the Schreiber’s bat, *Miniopterus schreibersii*, in Southern France: A LIFE-Nature Program Including an Autecological Study

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Comprehensive knowledge of roosting and foraging ecology is essential for conserving bats. Since 2004 a four-year program, funded by the European Community (LIFE-Nature “Chiroptères Grand Sud”), has been conducted by the French Mammal Society and 12 partners in Southern France to 1) protect roosts of three cave-dwelling bat species, including the Schreiber’s bat *Miniopterus schreibersii,* and 2) study their autecology, according to an Eurobats resolution. As it is commonly known, Schreiber's bats are gregarious and usually roost in different caves along the year. More interesting, females were observed switching roosts during the breeding season. So, realistic estimations of populations can only be obtained by monitoring simultaneously all the roosts of an area. In a colony of 4,000 adults, 21 females have been radio-tracked (average: 2.4 nights per bat) for four weeks during either pregnancy or lactation. Every night, each bat was active during 5 h 33 ± 57 min (pregnant) or 6 h 06 ± 38 min (lactating), foraging far from the roost (up to 35 km), on very small and different feeding areas. The mean individual home range was 10,837 ± 5,399 ha (pregnant) and 22,318 ± 7,141 ha (lactating). Urban areas were extensively used, providing the occurrence of white streetlights. Some bats also foraged in deciduous Mediterranean forests and in orchards. Preying mainly on Lepidoptera (95% of volume), Schreiber's bats were observed foraging in areas where preys were seasonally the most abundant, adapting their foraging behavior to food availability and possibly physiological requirements. The results show that the conservation of the Schreiber's bat must be planned at a very large scale. The priority should be given to the protection of a network of suitable roosts (hibernacula, transit and breeding sites) able to shelter large colonies. Then, efforts should focus on maintaining deciduous forests and promoting bat-friendly agricultural practices.

Bat Fatalities at Wind Energy Facilities in Germany

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Currently, Germany is the country with the largest capacity of wind energy production installed in the world. At the same time, all bat species are strictly protected by European and national nature conservation laws. The conflict between bat conservation and the installation of wind turbines has become an increasing issue since 2002, when the first bat fatalities were reported. Since then, 13 of the 23 bat species occurring in Germany have been found during fatality searches at wind energy facilities. However, just three of these species have accounted for approximately 80 percent of the carcasses: *Nyctalus noctula*, *Pipistrellus nathusii*, and *Pipistrellus pipistrellus* (just the first two species are known to migrate). Many of the reported fatalities have resulted from non-systematic fatality searches and only a few studies follow a methodical approach so far—including the correction of the number of bat fatalities found. Partly due to these methodological differences, the quantity of bat carcasses found varies greatly for different study sites with as much as 37.1 killed bats per turbine and year found in a forested area and no bat fatalities at other sites. Thermal imaging and acoustic detectors have been used to monitor bat activity in the rotor-swept area. To reduce the risk of collisions, provincial administrations have begun to deny construction permits at sites that carry high risks of bat collisions or have restricted the operation of turbines during certain periods of the year or during times of low wind speed.

Mathematical Modeling of Hovering Flight in Bats

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Many bat species are capable of performing complex and variable aerial movements that include powered flights as well as flight initiating vertical jumps. This is possible because bats have much greater control over wing shape, curvature, and camber. The multi-jointed elastic wing membrane of the bat acts as an aerofoil, while wing flapping creates vortices. This paper describes a mathematical model to simulate the variable geometry of the flapping of wings. The full three-dimensional equations of unsteady-state potential flow are used to calculate the lift and drag coefficients in hovering flight. At present the model is far too complicated to allow for any analytical solution. Therefore a numerical simulation approach is used to study the model under different conditions of loading. Preliminary results suggest that the present mathematical model is capable of reproducing some of the effects recently reported in the literature from wind-tunnel experiments, as well as observations of bats in flight.

Roost and Habitat Characterization of the Endemic Flat-headed Bat, *Myotis planiceps*, in Mexico

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The flat-headed bat, *Myotis planiceps* (Vespertilionidae), is a microendemic Mexican species restricted to Coahuila, Nuevo León and Zacatecas, inhabiting boreal montane forests (*Pinus* spp. and *Quercus* spp.) at an elevation above 2,000 m. Until 1970 this species was known only from three records, and in 1996 it was declared extinct by the UICN because of the lack of records. In 2004 our team rediscovered it. This is an insectivorous species that mainly feeds on Lepidoptera and Coleoptera, but because few have been collected, there is a lack of information about its biology and conservation needs. Nowadays its known habitat is heavily fragmented and threatened by human activities. Learning about its roost sites and activity area is a priority for the conservation of the species. Roost sites play a key role in bat conservation, because they serve as nursery and resting sites, providing protection against predators and weather. Roosting behavior has an impact on bat density, breeding and feeding strategies, social structure, seasonal movements, and even on local and global distribution. It also regulates bat thermal needs and economizes energetic expenditure when traveling to feeding and watering sites. The present study addresses the characterization of the roosting sites and surrounding habitat for the flat-headed bat. Preliminary results show that these bats prefer yuccas (*Yucca carnerosana*) that are 3–5 m in height as shelter and surrounding vegetation composed of *Pinus cembroides* and *Juniperus* spp. Fecal analysis is underway. Outcomes of this research will help to formulate a recovery plan for the flat-headed bat.

Conservation Management of New Zealand Bats: A Review of the Department of Conservation Recovery Program, 1995–2007

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New Zealand has two threatened bat species and a recovery plan has been developed. The first 10-years of the program focused on baseline ecological and management research including: inventory and monitoring; clarifying taxonomic status; life-history and habitat use studies; and rates and causes of population decline. Today, the emphasis is on applying recovery techniques developed over the last five years to eight evolutionary significant population units. Main threats are loss of rainforest habitat and predation by exotic mammals. A wide range of conservation techniques are being applied, including 1) statutory advocacy aimed at reducing habitat loss and mitigating potential human impacts; 2) advice and education; 3) control of exotic pests to increase productivity and survival of bats; 4) active protection of roosts sites and foraging habitats; 5) restoration of important habitats; 6) translocations to predator-free habitats aimed at establishing new populations; and 7) captive management. Progress has been encouraging, e.g., introduced rats (*Rattus* spp.) have been eradicated from some offshore islands that support bat populations. Integrated pest management at a landscape scale has commenced at some mainland sites with survival increasing by 30%. Legal protection of bat habitats has been effective in some localities. Maintenance in captivity is possible, but captive breeding and translocation have not been successful to date. It is too early to say how successful these techniques are across all populations because their application is recent, and responses to management are predicted to be slow.

The Bat Grid: A Standardized Approach to Surveying for Bats
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Research and management challenges associated with bat conservation, such as conducting inventories and monitoring strategies across the range of a species, benefit from a standardized sampling frame and protocol. Since 2002, such a sampling frame and protocol have been implemented in the Northwestern U.S. using a grid-based design. The sampling frame for this approach, known as “The Bat Grid,” also is available for North America in a GIS format. We present morphological, acoustic, and genetic summary data collected using this grid approach. We will provide an overview of The Bat Grid and present some of the benefits of implementing a large-scale standardized grid by highlighting our results to date.

Male Dominance, Paternity, and Relatedness in the Polygynous Mating System of the Jamaican Fruit-eating Bat (*Artibeus jamaicensis*)
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We assess the genetic structure, paternity, and relatedness of polygynous Jamaican fruit-eating bats. We used 14 microsatellite loci to analyze the genetic questions of the mating system. A total of 84 adults captured in two different caves exhibited little genetic differentiation (F_{st} = 0.008). Average relatedness among adult females in harem groups was very low (R = 0.014), giving no evidence of harem structure. Dominant and subordinate males shared paternity in large harem groups (more than 14 females), while dominant and satellite males shared paternity in smaller groups (less than 14 females). Our results suggest that male rank influences paternity. Dominant males fathered almost 70% of the new born in the harem groups, followed by satellites (22%) and subordinates (9%). Overall adult male bats are not directly related; however, in large groups we found that subordinate and dominant males are related, with values consistent with a father-son relationship. Because both males shared paternity in harem groups, we propose that their association provides inclusive fitness to them.

Ectoparasite Load and Bat Spleen Size in Temperate and Tropical *Macrotus* Populations in Mexico

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Recent comparative works across species indicate that animals allocate investment differently in immunological defense, depending on their exposure to ectoparasites, as measured by spleen size and other indirect responses. Ectoparasites probably have a major impact on their hosts in the tropics because they are more abundant than in non-tropical areas. The genus *Macrotus* (Phyllostomidae) in Mexico is represented by two species of bats with contrasting biogeographic distributions: *M californicus* in NW Mexico, and *M. waterhousii* in NW, Central and S Mexico. We measured ectoparasite abundance and richness from ten bats collected in a temperate *M. californicus* population (Sonora) and in a tropical *M. waterhousii* population (Colima). We collected all ectoparasites from each individual bat; insects and some acarines were preserved in 80% ethanol, and most acarines were preserved in Hoyer's liquid. Ectoparasites were counted and identified. We extracted the spleen from each bat and weighed it to the nearest mg. We tested the relationship between spleen size and parasite abundance as an indirect measure of immunological investment. We found lower ectoparasite abundance (219 individual) and richness (7 species) in the *M. californicus* population than in the *M. waterhousii* population (1,660 individuals and 18 species). Additionally we found a non-significant relation between ectoparasite abundance and spleen size in both populations of bats. [Financial assistance was provided by the Dirección General de Asuntos del Personal Académico, Universidad Nacional Autónoma de México, Grants IN221906 to J.B.M-M and IN207005-3 to L.G.H.M.]

Roost Selection by Three Frugivorous Bats (Chiroptera: Phyllostomidae) in the Lacandon Forest, Chiapas, Mexico

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In two different sites of the Lacandon Forest, Chiapas, Mexico, structural characteristics of tree roosts such as height, cover, and diameter were described and evaluated. Microenvironmental traits (temperature and moisture) were also assessed in each roost where three species of phyllostomid bats, *Artibeus lituratus*, *Carollia perspicillata*, and *Sturnira lilium* were present. Eleven day-roosts were located and described after a systematic search of trees in both sites. Telemetry was also used as a complementary method. Bat species preferred large roosts trees with more than one cavity. All roosts were located in areas of mature tropical forest or in advanced successional stages. The species preferred roosts in trees with lower values of moisture than those in the exterior (means with standard deviation) (81.04 ± 6.88%, on the inside against 93.56 ± 4.50% on the outside). Temperature was not an important trait for roost selection on trees for any of the bats studied.

Configuration Landscape of an Andean Fragmented Forest and Bat Diversity and Abundance

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An Andean landscape dominated by oaks (*Quercus humboldtii*), which has been fragmented and is immersed in an agricultural matrix, is described. Cartographic information was analyzed to determine several landscape properties and some fragmentation indexes. In this landscape four fragments were selected (10–50 ha) where a bat sampling was designed to describe diversity and abundance associated with matrix-interior gradient in the fragments. In these patches 24 bat species belonging to Phyllostomidae and Vespertilionidae were registered. Species richness and diversity were highest in the edge and matriz of fragments near to other landscape elements. In this landscape, 53 patches of sub-Andean and 111 of Andean forest were found, and fragmentation indexes reveal that Andean forests are less fragmented. This landscape has been very transformed; 90.4% of fragments are smaller than 50 ha and the 53.3% of total area has been modified. The sub-Andean forest is critically threatened; however, these patches support a high bat diversity and abundance, even though they have suffered high modification.

New Register of Rabies Bats for Rio Grande do Sul, Brazil

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The cases of rabies transmitted by bats in Brazil were linked frequently with *Desmodus rotundus*. However, since 1996, with the support of the institutions of health and especially the Centers of Zoonoses Control, cases were registered in bat species that are not hematophagous. Since 1998, the capitals of the states of São Paulo, Rio de Janeiro, and Belo Horizonte verified the presence of rabies in species such as *Artibeus lituratus* (frugivorous), *Glossophaga soricina* (nectarivorous), *Nyctinomops laticaudatus* (insectivorous), *Molossus molossus* (insectivorous), and others. In 1965, a case of rabies in *Tadarida brasiliensis* was registered in Rio Grande do Sul. Subsequently, between 2001 and March 2007, 1,143 samples of bats' brains were examined and 25 of them were positive for the rabies virus. Since 2004, after the registration of three cases of rabies in insectivorous bats (*T. brasiliensis*), the city of Porto Alegre is on constant alert for a new register. *Tadarida brasiliensis* is an important species in terms of public health, due to the size of its colonies (commonly greater than 1,000 individuals). Its ecological role is also significant because it is one of most predominant species in the city, consuming an enormous number of insects per night. By the way, according to research in process, it is an environmental indicator of species, that it is possible to verify the levels of insecticide present in the insects consumed by bats through the toxicological analysis of their feces and stomach contents, considered urban plagues.

Urban Bats of Porto Alegre's Metropolitan Area, Rio Grande do Sul, Brazil
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Bat studies in the metropolitan area of Porto Alegre, Rio Grande do Sul, Brazil, have been done since 1992. The area has 9,889.6 km^2 and, according to IBGE's estimates, in 2006, about 4.1 millions habitants were living there. That is why it considered the fourth most important area of Brazil and the 79th largest metropolitan area in the world. The area includes 31 municipal districts that are in intense horizontal union process. In Brazil, a lot of crendices and superstitions about bats still exist. Most of the people do not want bats in their roofs, next to their residences, and defecating in their cars. Also they fear that bats transmit diseases such as rabies and histoplasmosis. Actually, the people who have their roofs' lining, attics, basements, empty spaces of blinds and conditioned air or still in the gap-windown of dilation between buildings are full of bats. Then, they used to contact the bat specialists by phone calls and e-mails, to remove those mammals from their residences or yards. The state of Rio Grande do Sul has until the moment, 37 registered species, and 19 of them are living in the urban area, belonging to the families Noctilionidae, Phyllostomidae, Vespertilionidae, and Molossidae. Starting from these registrations in several places a database was developed with the following information: municipal districts, neighborhoods, types of shelters, families, species, diets, reproductive period, etology, displacement and dispersion, fidelity to the shelter, cohabitation, number of marked bats, size of the colonies. This database has been used in Porto Alegre to facilitate studies of colonies when bats are positive for rabies. The database will be able for others cities about October.

Flexibility in Sensory Strategy Use During Foraging in the Fringe-lipped Bat, *Trachops cirrhosus*
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The fringe-lipped bat, *Trachops cirrhosus*, hunts frogs and uses frog advertisement calls to detect, locate, and assess its prey. In nature, frogs cease calling when they detect an approaching bat. Thus, passive acoustic cues should not always be informative in prey detection. We hypothesized that rather than relying solely on prey-emitted acoustic cues, *T. cirrhosus* can utilize multiple sensory modalities for prey detection, localization, and assessment. Specifically, we asked: to what degree does *T. cirrhosus* rely on passive versus active acoustic cues for prey detection, and further, can this bat switch sensory strategies in response to foraging success? We presented bats with conflicting sensory cues: a speaker broadcast frog calls from one location, while a real frog was positioned 30 cm away. Wild-caught bats consistently approached the frog calls and were unsuccessful in locating the real, displaced frogs. In a mean of 22.5 conditioning trials, in which active cues were enhanced and passive cues were diminished, bats learned to weight echolocation cues more heavily than passive acoustic cues and succeeded in capturing the silent, motionless frogs. Echolocation call structure did not differ for passive versus active approach sequences, but active sequences consisted of more total calls, decreased interpulse intervals, and increased call groupings. Further experiments confounded echolocation and passive acoustic cues with chemical cues. Even with conflicting sensory information, the bats

were able to rapidly identify and avoid poisonous prey. Our results demonstrate that this bat is highly flexible in its ability to switch sensory strategies in response to foraging success, and can rapidly adjust its use of specific sensory cues with experience.

Preliminary Population Genetic and Phylogeographic Results in the Cave Myotis (*Myotis velifer*) across Texas

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The cave myotis (*Myotis velifer*) is a fairly specialized, cave-dwelling species. Due to recent population declines, the cave myotis has been listed as a species of concern throughout much of its range. These concerns have brought questions of relatedness, site fidelity, and population genetic structure among occupied caves. To address these, wing tissue samples were collected throughout its range in the State of Texas to examine population structure, if detected, among sites. Results from analyses may indicate the severity of population declines when ecological and genetic aspects are compared with other chiropteran species listed as threatened or endangered. Preliminary results (n = 49 of approximately 300 collected specimens) propose three haplotypes based on the first 400 bp of the cytochrome *b* gene (11 parsimony-informative). These three haplotypes do not provide phylogeographic structure, except in the case of haplotype B, which has not yet been observed in any specimens from the Texas Panhandle. Furthermore, haplotype B has been observed in only one Central Texas specimen, which may have been a seasonal migrant. Haplotypes A and C appear to be evenly distributed throughout the Texas range of the cave myotis indicating a lack of female philopatry. Current work is underway to complete the sequencing of the cyt *b* gene and affirm the information provided by the preliminary haplotypes. Furthermore, cross-species amplification of microsatellite primers available in the literature is underway to explore migratory patterns or other fine scale genetic signals in the cave myotis.

Conservation Lessons from the Grey-headed Flying Fox, *Pteropus poliocephalus*, a Persecuted Species that Didn't Go Extinct in the 1930s!

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There has been considerable scientific interest in the endemic Australian Grey-headed Flying Fox (*Pteropus poliocephalus*), but wider opinions on this threatened species are strongly polarized. The coastal distribution of *P. poliocephalus* overlaps with extensive human settlements in eastern Australia resulting in conflict over land and resources. The species was considered a pest of orchards, a "plague" animal, and killed in large numbers—yet it has little capacity to withstand high mortality. Serious declines in population numbers reported throughout the 20th century and the persecution of this animal can be linked to the destruction of forests and the native blossom it feeds on. Its "pest" status was changed to "protected" in 1986 and, after another population decline it is now considered "vulnerable" under both State and Federal legislation. Here we review the current ecological knowledge on *P. poliocephalus* using a framework that highlights this as a species defined by contradictions. An easy animal to observe (it is numbered in the hundreds of thousands) but until recently, it was difficult to catch. It is considered a single population, yet it is spatially distributed into colonies that are reproductively active and have existed at set locations for decades. It is highly mobile, but individuals return to particular locations to roost and feed. It has a wide range of diet, however only the best of available foods are eaten. It is considered a fruit and blossom feeder, yet it eats large numbers of insects. It is a wild animal, but over the last twenty years it exists increasingly in permanent urban colonies. *Pteropus poliocephalus* can be viewed as a model of a species that despite its low intrinsic rate of increase has so far survived against the odds. Long-term conservation of such species may rely on understanding how the combined strategies "spread the risk" of extinction.

Dietary Variation in Spectacled Flying Foxes (*Pteropus conspicillatus*) of the Australian Wet Tropics

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The diet of *Pteropus conspicillatus,* a large flying fox, was examined by collecting feces in traps beneath daytime roost trees in four geographically distinct camps in the Wet Tropics bioregion of Northeastern Queensland, Australia. Fecal analyses revealed that *P. conspicillatus* utilize a broad variety of plant resources from a variety of habitats. Seed and pulp from figs (*Ficus* spp., Moraceae) and pollen from the family Myrtaceae were most frequently represented in the feces from a range of both wet sclerophyll and rainforest habitats. The dietary composition of *P. conspicillatus* at individual camps could not be predicted by the habitats located within a typical foraging distance of each camp (20 km), and although consistent dietary changes were seen across all camps over time, each camp had a unique dietary signature indicative of feeding on a distinct subset of available vegetation. The unique diet of each camp and the variety of dietary items consumed suggest that camps may need to be managed on an individual camp-specific basis, and that *P. conspicillatus* are utilizing a broader range of resources than would be expected if the species was a strict 'rainforest-fruit specialist'. Viable bryophytes and other organisms were found in *P. conspicillatus* fecal samples, implicating *P. conspicillatus* as a disperser of a wide range of organisms other than the propagules of angiosperms. The two aspects of this study have broadened our knowledge on the feeding ecology of *Pteropus conspicillatus* and raised new questions about interactions between flying foxes and other organisms.

Biomechanical Linkage of Echolocation and Limb Movement During Flight and Quadrupedal Locomotion in a Terrestrially Agile Bat (*Mystacina tuberculata*)

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The energetic costs of flight and of the production of high intensity echolocation calls, when considered separately, are extremely high. However, respiration and wing beat share several major muscles in common and many bat species have been shown to link these core activities, thus reducing their overall energetic cost. Based on these results, it has been suggested that small terrestrial mammals that echolocate will produce lower intensity echolocation calls because they are unable to offset the cost of call production. We tested this suggestion by studying the echolocation behavior of *Mystacina tuberculata* during flight and terrestrial locomotion. *M. tuberculata* is a highly terrestrial bat endemic to New Zealand that forages for insects, nectar, and pollen aerially and terrestrially. We tested the null hypotheses that *M. tuberculata*: 1) does

not link wing beat with echolocation call production during flight; 2) does not link echolocation call production with limb movement during terrestrial locomotion; and 3) does not produce lower intensity echolocation calls during terrestrial locomotion than are produced during flight. Using high-speed video and audio recordings we reconstructed the bats' position in 3-dimensional space allowing us to determine the timing of echolocation calls in relation to phase of wing-beat/foot fall. We were also able to calculate the rate of echolocation call production and call intensity during terrestrial and aerial locomotion. Results from this study are discussed in terms of biomechanics and the energetic cost of echolocation during terrestrial locomotion and the unique terrestrial niche occupied by *M. tuberculata*.

A Three-year Study on the Diets of *Myotis volans*, *M. evotis*, *M. thysanodes*, and *M. lucifugus* in Boulder County, Colorado

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Many insectivorous bats share and forage for food within the same habitats, often capturing and consuming similar types of prey. Four such species living in the same environment in Boulder County, Colorado are *Myotis volans*, *M. evotis*, *M. thysanodes*, and *M. lucifugus*. This three-year study was conducted to determine if variation in diets existed between the species and to determine if resource partitioning between species was occurring. Bats were collected by setting up mist nets at six different water holes in the foothills of Boulder County, Colorado from May to September 2004–2006. Individual bats were placed in capture sacs for at least 30 min to get an adequate fecal sample. Fecal samples were taken back to the lab for analysis. The boluses of each sample were separated for individual identification. Insect parts were separated and identified using various insect references and keys. After all samples were processed, they were examined a second time to account for accuracy. Percentages based on insect order were determined for each species and compared. More than 85% of the diet for *M.* volans, *M. thysanodes,* and *M. lucifugus* was made up of Lepidoptera, Diptera, and Coleoptera, while Lepidoptera, Coleoptera, and Hemiptera made up 93% of the diet for *M. evotis*. A chi-squared test was run to determine if the consumption of insect orders varied among the *Myotis* species. The chi-squared test showed a significant difference in consumption of insect orders by the five species ($\chi^2 = 68.80$, $p < 0.001$). The difference in diet could be explained by different feeding strategies and resource partitioning to decrease competition but further research needs to be done to determine this.

Assembling Changes of High Mountain Cloud Forest Chiropterans in Response to Habitat Fragmentation

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The Colombian high mountain cloud forests are very important because of their role in the regulation of water sources for the main cities of country. Only 27% of the cloud forest remains from original forest area due to agriculture and grazing activities. Bats represent 32% of the mammal fauna of this habitat and their importance into pollination and dispersal functions are well documented. To evaluate the response of bats to the effect of habitat fragmentation, we compared the diversity and density between two fragments and two continuous forests.

Simultaneously, we evaluated some factors that probably are responsible for the changes found in the bat assembly. We registered the diversity, abundance, and trophic structure of bats monthly from January1998 to December 2000. Additionally, we measured the abundance of flowers, fruits, and night insects (Lepidoptera and Coleoptera) and vertical and horizontal structure of vegetation. We related bat assembly changes with changes in food offer and vegetation structure by means of path analysis models. We found that temporal variation in all guilds was correlated with food offer. The response of each guild was differential because only the richness of frugivorous bats decreased. The absence of frugivorous bats was explained by decreased foraging space, which is due to an increased growth of secondary species that increased the vegetal covertures. Finally, we present a dynamic model that explains the mechanisms that affect bat diversity and can be used in management and conservation planning.

Functional Groups of Bats Associated to Natural and Transformed Systems in the Colombian Coffee Ecorregion

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In the Eje Cafetero Region (Colombia), approximately 20% of the natural forest persist as immerse fragments of the productive systems dedicated to agriculture and cattle raising. The changes in the functional role of bats will depend on the nature of the matrix surrounding the fragments and the present vegetation coverage. The structure and the assemblage composition of bats are described in natural and transformed environments (regional productive systems of extensive cattle raising for meat and/or milk) in Risaralda and Quindío (Colombia, South America) (2005–2006). The type of vegetation cover (forest, guadual, high grasses, shade coffee plantation, and perennial crop) was considered. Mist nets at different heights were used. The forests showed the most amount and richness in species, followed by guaduales, crops, and high grasses. Complementariness was low in forest, but high in crops and high grasses. The greatest variety of functional groups was found in forests. Pollinators were more abundant in the coffee plantations; in the grasses only seed dispersers were found. The structure and composition of assemblage is simplifying locally. The increase in the complementariness on a regional level reflects that the functional groups have very concerning differential answer to the type of vegetation cover present.

Noninvasive Genetics: New Tools for the Study of Bat Population Ecology

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Noninvasive genetics consist of analyzing DNA extracted from animal tissues that are left behind by individuals: shed hair or feathers, feces, urine, among others. These techniques are used routinely to monitor or study populations of rare or elusive species, or species that are difficult to manipulate, such as bears in North America. They have, however, been of little use in bats although important quantities of guano, which is a potential source of DNA, can be found in the roosts of many species. We will illustrate that different questions of bat population ecology can be studied using these tools. Using the lesser horseshoe bat as an example, we demonstrate

that bat droppings are a valuable source of very good quality DNA. This DNA was amplified at polymorphic microsatellite loci to identify individuals, yielding data that resemble capture-mark-recapture data. These data were then used to estimate colony sizes in three French nurseries for which we also had independent visual censuses. By sampling each colony once a year over two years, we were able to obtain accurate and precise estimates of colony sizes. The same protocols were used to estimate allelic frequencies in 18 nurseries of the lesser horseshoe bat in Brittany, with the aim of estimating the relative isolation of colonies, and the influence that landscape features have on gene flow. The comparison of least-cost path distances with genetic distances showed that forest cover has no influence on the connectivity between nurseries in this region. We found however that dispersal distances are much more limited in the lesser horseshoe bat than the Bechstein bat, another forest-dwelling species characterized by restricted mobility. These examples show that noninvasive genetics provide an interesting toolbox for the study of various questions in bat functional and evolutionary ecology.

Threats to the Bats of Curaçao (Netherlands Antilles) and Factors Influencing the Evaluation of Their Status

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Surveys of the bats of Curaçao took place in 1993 and 2003, showing the decline of several of the seven species, in particular *Mormoops megalophylla intermedia*, which risked imminent extinction. A survey conducted just prior to the conference in 2007 will establish the current status of the bats. Threats affecting the bats include rampant urbanization accompanied by habitat destruction and disturbance of the roosting sites. Difficulties in surveying bats, such as movements between caves and possibly other locations than Curaçao, structural irregularities of caves, incomplete knowledge of caves, fragility of bats, and lack of funding may affect the accuracy of their census. Population fluctuations within a year also indicate that long-term monitoring is a necessity to understand population status and conservation needs. Currently, the species with the widest niche breadth, such as *Glossophaga longirostris elongata*, are the most likely to survive on Curaçao. International assistance is needed to protect the most important caves, based on species representation and reproduction.

Male Reproductive Activity in Hibernating Bats Indicates Early Male Advantage

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Reproduction in hibernating bats from the temperate zones is shaped by a highly seasonal and predictable environment. Females exhibit sperm storage and delayed ovulation. During optimal food availability in the summer, male bats produce spermatozoa in their testes, which are released to the epididymes in late summer to early fall. During this period, many species accumulate at caves and display swarming behavior. In order to investigate interspecific differences in annual activity patterns, we mist-netted bats during their active season at a cave over three consecutive years. Additionally, we measured testis and epididymis sizes and thereby assessed the progress of male reproductive status in four sympatrically occurring species. We found no variation in spermatogenic timing over the years within species, indicating consistent annual male reproductive seasonality. However, we observed marked deviations in the annual spermatogenic timing of almost two months between species. As a general pattern, all four species underwent maximal spermatogenic activity shortly before females abandoned their nursery colonies. Afterwards, males and females met at the cave and displayed swarming behavior. Within this period, epididymes reached their greatest volumes and regressed considerably until the end of the swarming period. We argue that female availability rather than climatic and nutritional factors triggers the male spermatogenic timing. Furthermore, we conclude that the swarming period constitutes the main mating period and later copulations are less important. Due to the close matching of male reproductive activity and early female availability, we propose that the mating system and reproductive timing in these species is governed by an early male advantage within a regime of intense sperm competition.

Cryptic Speciation in *Craseonycteris thonglongyai*?

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A recent study indicated that the two known ‘populations’ of the monotypic bumble-bee bat, *Craseonycteris thonglongyai*, from Thailand and Myanmar, exhibit an 8–10 kHz difference in echolocation call peak frequency, suggesting that they may be different species. However, morphological investigations comparing both populations failed to find any variation between the Thai and Myanmar populations, although the number studied was low. These results raised important questions about the possible presence of cryptic species and the validity of echolocation call variation to define species boundaries. To investigate this possibility we used molecular markers (mitochondrial and nuclear DNA) to study the evolutionary relationships between individuals from different localities. We recorded echolocation calls from different caves throughout the entire known distribution range in Thailand and Myanmar and compared this with our molecular data. The patterns of population structure inferred from different DNA markers, echolocation calls, and morphological data were analyzed and described.

Bats on the IUCN Red List: Global Patterns and Conservation Assessments

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Although the majority of extinctions of vertebrate animals since 1500 AD have occurred on oceanic islands, large numbers of continental species also are now at risk. We describe the Global Mammal Assessment, a comprehensive review of the conservation status of all species of mammals and its role in updating the IUCN Red List of Threatened and Endangered Species. We examine species richness, levels of endemism, conservation status, zoogeography, and extinction threats for bat species across the globe. Oceania, with high species richness and significant endemism (1 family, 8 genera, and 101 species) is of special concern because many taxa are limited to small geographic areas. Recent updates to the IUCN Red List place 22% of the bat species in Oceania in threatened status, while a further 35% are considered “data deficient” or “not assessed.” Conservation threats to bats in Oceania include vulnerability to stochastic events such as volcanic explosions and cyclonic storms, predation by humans for bush meat, disturbance to roosts, climate and sea level change, and loss and fragmentation of forests. Globally, the Pteropodidae contains the largest number of threatened species from any family. Pteropodids are prone to severe population reductions because they have low fecundity, are important sources of human protein, and often have small geographic distributions. Using New

Guinea and Panama as examples, we illustrate that bat species richness rapidly declines with elevation. Additional protected reserves in lowland tropical forests are of crucial importance for the preservation of global bat diversity.

Bat Collisions with Wind Turbines: Can Radar Provide a Means of Mitigation?
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Large numbers of bats are killed by collisions with wind turbines and there is at present no direct method of reducing or preventing this mortality. We therefore determine whether the electromagnetic radiation associated with radar installations can elicit an aversive behavioral response in foraging bats. Four civil air traffic control (ATC) radar stations, three military ATC radars, and three weather radars were selected, each surrounded by heterogeneous habitat. Three sampling points matched for habitat, altitude, and surrounding land class were located at increasing distances from each station. A portable electromagnetic field meter measured the field strength of the radar at three distances from the source: in close proximity (< 200 m) with a high electromagnetic field (EMF) strength of > 2 volts/meter, an intermediate point within line of sight of the radar (200–400 m) and with an EMF strength of < 2v/m, and a control site out of sight of the radar (> 400 m) and registering an EMF of 0 v/m. At each radar station bat activity was recorded three times with three independent sampling points monitored on each occasion, resulting in a total of 90 samples, 30 of which were obtained within each field strength category. Bat activity and foraging effort per unit time were significantly reduced in habitats exposed to an EMF strength of greater than 2 v/m when compared to matched sites registering EMF levels of zero. Even at sites with lower levels of EMF exposure (< 2 v/m), bat activity and foraging effort were significantly reduced in comparison to control sites. Our results suggest that radar may have the potential of providing a means of preventing bat deaths as a result of collisions with wind turbines.

Bats in Agro-ecosystems: The Role of GIS and Multivariate Models to Understand Foraging Habitat Suitability
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Most habitat selection studies tend to evaluate foraging suitability for bats using just the land cover type as a predictive variable. However, bats select their foraging sites not just based on land cover but also on other variables such as distance to the roost, soil quality, and distance to waterlines. We used a methodology that allows the inclusion of multiple layers of spatial variables to identify and map habitat suitability for bats, using Geographic Information Systems and logistic regression. To exemplify this approach a spatially explicit foraging suitability model was developed for two cave-dwelling species (*Rhinolophus mehelyi* and *Miniopterus schreibersii*), both of global conservation concern and among the least known bats in Europe. The study was done in a farming area in southern Portugal included in the European Natura 2000 network. The resulting models suggest that in the study region land cover is not one of the major factors determining habitat suitability for foraging *R. mehelyi.* Suitability is instead significantly associated with soil productivity and with the distance to waterlines. In the case of *M. schreibersii* suitability is mainly associated with the distance to roost and distance to waterlines, but also with land cover. The models allowed the development of maps predicting foraging suitability in the study area. They illustrate the dependency of both bats on agro-ecosystems, and how farming practices can affect foraging habitat. The best soils, preferred by *R. mehelyi,* tend to be used for the most intensive agriculture, thus are more likely to be subjected to pesticides or even sealing practices that exclude bats. In the case of *M. schreibersii* changes in land cover due to agriculture can affect the foraging potential of habitats. In this study GIS and statistical modeling techniques proved capable of generating predictive multivariate spatial models, which can aid in the inclusion of bat foraging requirements in the management of landscapes.

A Novel Behavior of Depositing Masticated Plant Materials Inside Tent Roosts in the Fruit Bat *Cynopterus sphinx* (Chiroptera: Pteropodidae), in Southern India

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We observed deposited plant materials inside palm roosts of the tent-making bat *Cynopterus sphinx* in and around Madurai, Tamil Nadu, India. Herein, we describe a new behavior of depositing masticated green plant materials on the interior of the palm tents. Our observations and videography revealed that typically only males deposit masticated green plant materials on the interior of their roosting tents. Males T7 and T3 spent 6.4 ± 0.6 h (n = 8 nights) and 5.8 ± 0.7 h (n = 6 nights), respectively, in the new tents that were being constructed by them and spent 0.74 ± 0.2 h and 0.56 ± 0.1 h in licking the interior of the tent, and 3.8 ± 0.6 h and 4.4 ± 0.4 h for foraging, respectively. Though both of these males were observed to lick the interior of the new tents being constructed, no obvious markings were observed during this study. Further observations on other males revealed that they deposited plant materials. T2 and T27 spent more than 60% of the time (T2: 6.7 ± 0.9 h, n = 9 nights; T27: 6.4 ± 1.3 h, n = 10 nights) inside the tent interspersed with many short foraging bouts. The number of foraging bouts per night varied from 12 to 41 and each foraging bout varied from 28 s to 48 min. T2 and T27 spent 0.8 ± 0.3 h and 0.65 ± 0.2 h in actively depositing the plant material inside the tent and 4.0 ± 0.6 h and 4.2 ± 0.5 h in foraging, respectively. We identified the fruit rind of the ‘wild lime’, *Atalantia monophylla* (Rutaceae) as one of the deposited plant materials (in the majority of tents). Direct observations and videography showed that the leaves of *Cephalandra indica* (Cucurbitaceae) were also deposited inside tents. We suggest that the deposited plant materials may advertise resource richness (food) within that particular habitat or may serve to attract females or may advertise roost occupancy or ownership, or the included plant material may serve to control roost-borne ectoparasites and microorganisms.

Testing and Quantifying Habitat Selection by Bats: Using Simulations to Analyse Radio-tracking Data

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Knowledge of habitat selection by bats is essential for their management and conservation. Radio-tracking data are often used to obtain such knowledge by comparing how much bats use each habitat to its availability. If bats do not have preferences they use each habitat proportionally to its availability, whereas preferred habitats will be used in a proportion greater than that of availability. This rationale is only valid if habitat availability is correctly measured. It is usually assumed that availability of each habitat is a direct function of the area covered by the bats in a region around the roost, but this approach has a serious shortcoming: it does not allow the inclusion of spatial and behavioral constraints that may influence the availability of habitats to bats. We studied the performance of this approach using simulated scenarios in which we controlled the levels of selection. Tests using conventional estimates of availability resulted in numerous Type I and Type II errors. We present a simulation-based method to test for habitat selection that intends to overcome these problems. It is based on the generation of null models of habitat availability that are under the same spatial and behavioral constraints as the studied animals. The trajectories of radio-tracked bats reflect these constraints so they can be used as a base for the simulations that create the null models. The results of the application of these methods to our controlled scenarios demonstrate that they are superior to the conventional methods. The advantages of the proposed method are also illustrated with radio-tracking data of *Myotis myotis* in Southern Portugal.

Beetles, Bats and the Boreal Forest: The Effect of Beetle Infestation, Logging and Forest Fire on Bats in Southwest Yukon, Canada

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Natural disturbance regulates many key processes in the boreal forest. Forest fire and insect infestation are two of the most important natural disturbance agents affecting species composition, forest structure, and nutrient cycling. Anthropogenic sources of disturbance such as logging can also have substantial impacts on ecological processes and structure. The current spruce beetle (*Dendroctonus rufipennis*) infestation in northwestern North America is the largest on record. Large-scale insect infestations are of concern because it may reduce wildlife habitat, aesthetic value, and timber value, and may lead to an increased risk of forest fire. Typical management response to this disturbance agent is to salvage log or use fire to mitigate damage caused by insects. Our objective is to gain a better understanding of how bat habitat use differs in response to anthropogenic versus natural forest disturbance. We acoustically sampled summer activity levels of little brown bats (*Myotis lucifugus*) in beetle infested, clearcut logged, and burned boreal forest. Remotely deployed Anabat detectors were used to monitor relative bat activity in each of three disturbance types (logged, burned, beetle infested) in southwestern Yukon, Canada (60.8^0 N, 137.5^0 W). Five replicates of each disturbance type were sampled ($n = 15$ sampling sites), resulting in a total of 176 detector-nights of acoustic sampling. Structural characteristics of each site were recorded, including tree density, canopy cover, and others. Beetle infested forests were more structurally complex than logged or burned sites, the latter of which were very open. Bat activity was higher in the beetle affected versus logged and burned areas, but not different between burned and logged areas, as these sites were structurally similar. It also appears that the length of night affected bat activity in different disturbance types and that there are seasonal changes in bat activity.

Population Dynamics of *Tadarida brasiliensis mexicana* at Cueva del Guano, Durango, Mexico

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Cueva del Guano is located in eastern Durango state, near the Torreón-Lerdo Metropolitan area. This cave is on one of the proposed migratory paths of *Tadarida brasiliensis mexicana*, and

a bat banded in Carlsbad Cavern, New Mexico was recovered in it. We observed, sampled, banded, and released bats monthly for 13 months in 2005 and 2006 to 1) estimate population size and fluctuations by means of counts at emergence time, and 2) estimate sex ratio, relative age, and reproductive condition of random samples of 100 individuals. The ultimate goal was to document the use that bats make of this cave and its importance as a refuge for migratory populations. The cave is occupied all year by *T. brasiliensis*. Population size ranges from at least 2,524 bats in March to at least 19,360 in September. Sex ratios, ages, and reproductive condition suggest that the cave is used as a roost by two groups of free-tailed bats. In March a small colony of males and females inhabits the cave, where they probably copulate. In May–June a group of females, at least some pregnant, arrives in the cave and soon leaves together with the resident ones, leaving the cave inhabited by males. In September–October, females and males return, some continue their trip, whereas others stay and spend the winter in the cave. Clearly, this is an important refuge for migratory *Tadarida brasiliensis* and should be protected.

Impromptu Flight Rooms and the Sensory Ecology and Foraging Behavior of Wild-caught Bats

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Results from echolocation experiments employing psychophysical methodologies originating from traditional experimental psychology may distort our understanding of how most bats perceive their auditory worlds within a biologically relevant context. For one, although laboratory studies have shown that some species of echolocating bats can discriminate sub-millimeter differences between objects with respect to both size and distance, field studies show that bats will chase and attempt to capture inanimate/inappropriate targets and can be caught using traps that should be detected by the bats if they were working to their ultimate (i.e., lab demonstrated) capabilities. For another, lab studies may inadvertently allow for the formation of spatial memories of familiar spaces. In the lab, spatial memories may allow for the cessation of echolocation behavior, but in the field, whether or not bats have the opportunity to form useful memories and act on them has yet to be convincingly demonstrated. I will discuss some tried and tested materials and methods that exploit the natural predispositions of bats for the purpose of understanding their real world sensory ecology and foraging behavior and their potential evolutionary/ecological impact on would-be prey.

Combining Predictive Modeling with Genetic Analysis to Determine Postglacial Colonization Routes in Europe

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To determine glacial refugia and post-glacial colonization routes in Europe for the rare western barbastelle bat, we used the Maximum Entropy presence-only modeling algorithm and analysis of two mtDNA regions. Modeling results showed that barbastelles occurred throughout Europe during the last inter-glacial (Eemian, ~120k years before present) as well as in the present period, although during the former its distribution seems to be located further north. This could be linked to a climate that allowed the development of broadleaf forests in northern latitudes. During the Last Glacial Maximum we predicted three glacial refugia in Europe: Iberia, Italy, and Balkans-Turkey. However, the model also identified one refugium in northern Africa in the Atlas Mountains. Regarding genetic analysis, several haplotypes were found in Europe for mtDNA d-loop and cytochrome *b*. Haplotype diversity was greater in southern latitudes. Additionally, its composition in northern latitudes seems to be associated with the distance to the nearest glacial refugia, indicating that there could have been no major barriers for barbastelle colonization of Europe. Moreover, it is very interesting to find a shared haplotype between two glacial refugia: Iberia and Italy. This may have resulted from the post-glacial colonization of Europe by Iberian populations. Their genetic footprint could have spread to Italy, while Italian populations had no success in spreading out to Iberia. Alternatively, both refugia might have had some gene flow through North Africa during the glacial periods thus making the common haplotype a North African legacy that had much more success establishing in Iberia (probably via Gibraltar) than in Italy (via Sicily). In conclusion, past predictive modeling seems to be a powerful tool for studying population origins when combined with genetic analysis. Genetic results reveal footprints from repeated past events, and modeling puts these events into a continuous spatial representation.

Ground Validation of Presence-only Modeling on Rare Species

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The distribution of the rare western barbastelle was modeled for Portugal using Ecological Niche Factor Analysis (ENFA) and Maximum Entropy (Maxent) presence-only techniques. For that purpose, we used a set of climatic variables, altitude, and land cover. ENFA coefficients showed that the presence of barbastelles is linked to lower temperature ranges than found on average in Portugal and the bats prefer higher altitudes while avoiding human infrastructures. Barbastelles also seem to avoid agricultural fields and production forests, and prefer areas with higher levels of precipitation. Another outstanding feature was the preference for denser areas of native woodland. Regarding Maxent results, the most important variable for the model was native woodland while annual average temperature was the most important abiotic variable. In order to ground validate the GIS models, acoustic surveys were conducted in areas identified as suitable or unsuitable by both models (Maxent and ENFA), as well as in areas where the models had divergent predictions. Moreover, Kappa statistics were also used to test the models for differences. Both models predicted similar suitable areas in the north and center of the country, while some discrepancies were found in the southern part. Nevertheless, acoustic surveys confirmed the presence and greater abundance of barbastelles in the majority of the predicted areas. Overall, predictive modeling seems to be a powerful tool when studying species distribution, especially for conservation decision-makers. For example, with this study, the presence of the rare barbastelle was determined in areas where it was previously unknown although predicted as suitable by the models, thus greatly contributing to a better management of its populations.

The Influence of Riparian Vegetation on the Distribution and Abundance of Bats in an African Savanna

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Riparian habitats are known to be important habitat for bats; however the factors influencing the distribution of bats in African savannas are largely unknown. We sampled savanna and riparian habitats in Swaziland's lowveld for bat activity from 2004–06 using mist nets and a harp trap. We found riparian sites overall had higher bat activity, diversity, species richness, and abundance. One species, *Epomophorus wahlbergi*, accounted for 52.6% of captures. Seasonality had no effect on overall captures, nor did distance from the nearest riparian habitat for savanna sites. Echolocation guilds were correlated with vegetation characteristics; CF and FM bats were captured more frequently at sites with greater bush density, while FM-QCF and QCF bats were captured more frequently at open sites.

Opportunistic Omnivory: The Key to the Ecological Success of the Most Speciose Mammalian Assemblages

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Phyllostomid bats exhibit the widest spectrum of diets within any mammalian family, ranging across all trophic levels. Much work has been done on their feeding ecology and species have been grouped into ensembles according to their dietary specialization. However, there is no consensus as to names and number of ensembles within an assemblage, nor has there been statistical proof for differences in diet amongst ensembles. In this study we argue that phyllostomid bats are more omnivorous than previously suggested. We analyzed the diet of 67 phyllostomid bat species based on fecal analyses as well as on nitrogen isotope ratio of wing tissue. Even though some species show morphological adaptations that display them as dietary specialists (e.g., long tongues in nectar-feeding bats) they constantly complement their major diet with carbohydrates or proteins, respectively. We were unable to group species according to their diet. Grouping bats into ensembles might induce misleading assumptions with respect to interspecific competition. Our results suggest that phyllostomid species have successively specialized on distinct diets during their radiation without sacrificing their capability to collect and digest a large variety of food types. This combination of specialization on one hand and opportunistic omnivory on the other may be the key adaptation that promoted their radiation throughout the Neotropics and allows them to form assemblages of higher species richness than any other mammalian family.

How Many Markers Should Be Used to Study the Complex Kinematics of Bat Flight?

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When bats fly, they fold and move each wing in complicated ways. To accurately reproduce those body motions, or kinematics, it is necessary to track several points on the wing independently, but it is not known how many such markers are needed for a model to accurately reproduce movement, or where those markers should optimally be placed. Too few markers will result in underestimating dimensional complexity, while too many will increase the amount of time required to digitize marker positions, without adding information about complexity of movement. Poor selection of marker locations can have either (or both) of these effects. Proper Orthogonal Decomposition (POD) is a computational tool mathematically equivalent to Principal Components Analysis that can be applied to quantify or sometimes reduce the dimensional complexity of motion. We applied POD to a series of markers on a bat (Pteropodidae: *Cynopterus brachyotis*) flying in a wind tunnel in nine trials, each at a different speed. In each trial we independently measured 46 dimensions of motion, using 2 markers on the body, 15 markers on the joints and tips of bones on the left wing and hindlimb, and a body-referenced linear coordinate system centered at the anterior sternum. Using POD, we found that regardless of speed, > 30% of flight motion could be reconstructed using a single linear variable, and > 95% constructed using as few as 16 of the 46 variables. For each number of wing markers (1–15) we found the 'optimal' set, defined as that which resulted in the greatest dimensional complexity for a given number of wing markers. Our results suggest that the hindlimb moves independently from the rest of the wing, and should always be tracked. Also, the motions of different parts of digits III and IV are quite independent, so where capturing dimensional complexity is the goal, several markers should be placed on those digits, even at the expense of any markers on digit V.

Analysis of Echolocation Calls from Fourteen Species of Aerial Insectivorous Bats of Morelos State, México

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Bats are subject to conservation problems, and to be able to estimate and take measures for this problem it is necessary to know population fluctuations and to identify important habitats where bats concentrate. In the case of aerial insectivorous bats, their ability to fly and their capacity to detect mist nets make it almost impossible to design monitoring programs that provide information on abundance and habitat use. However, while foraging, they emit echolocation calls, which allows the application of acoustic methods. The purposes of this study were to describe the echolocation calls of aerial insectivorous bats occurring in Morelos using the time-expanded recording, and to evaluate the possibilities of discrimination among species using 15 call parameters. Bats were captured in different points of the state, and 14 species belonging to the families Molossidae and Vespertilionidae were recorded. Echolocation calls were digitalized and analyzed with a BatSound (Petterson Elektronik). Multivariate discriminant function analysis was applied to call parameters of 11 species. A function based on final frequency, middle frequency, minimum frequency at -25 dB, final minimum frequency, and frequency of maximum energy provided a correct overall classification of approximately 82%. Although there were limitations, this approach allows information to be obtained about the presence of a large number of species, and provides the first catalogue of bat sounds of Morelos state.

Trophic Influences in Mandible Shape Variation of Phyllostomid Bats
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Phyllostomids comprise a large clade of Neotropical bats (57 genera and 184 species) with unusually high levels of morphological and ecological diversification. The trophic radiation observed within this group has no parallel among mammalian families, and is expected to have strongly influenced morphological divergence. Here we examine shape variation in the mandible of phyllostomid bats and its relationship with diet. The mammalian mandible is a good model to study shape-diet relationships because most of its components are primarily related to food processing. Geometric shape descriptors (partial warps) were obtained from a sample of 433 specimens representative of 49 species and genera. Through a direct gradient ordination method (Partial Least Square), pairs of axes explaining covariances between a matrix of shape variables and a matrix of diet information were extracted. No single pair of axes explained a significant amount of covariance between shape and diet, but the cumulative that explained covariance of the four first axes is highly significant (99%), suggesting a complex multidimensional pattern of association between mandible shape and diet. These four first axes, organized from greater to lower covariances, contrast, respectively, sanguivorous vs. nectarivorous and insectivorous bats, sanguivorous and nectarivorous vs. frugivorous, frugivorous and nectarivorous vs. carnivorous and insectivorous, and carnivorous vs. insectivorous. Major trends in shape variation related to the same axes are, respectively, extension of the mandibular corpus and relative position of the canine, relative development of masseter and coronoid regions, relative extension of premolar and molar tooth rows, and robustness of the alveolar anterior region. Data will also be considered under a phylogenetic context.

Program for the Conservation of Bats of Costa Rica (PCMCR)
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Costa Rica has great bat diversity, with 110 species (11% of the world's total) in only 52.000 km^2. However, it has suffered an accelerated deforestation, which has led to the loss of 60% of its forest coverage in the last 50 years. From this arises the urgent need to study and protect the bats of the country. Thus, the Program for the Conservation of Bats of Costa Rica (PCMCR) was created in 2001 with two main components: education and research. The educational component consists of workshops that initially target children in the 4th grade, with follow-up over the next 3 years. Each year a different character is presented, representing the different types of bats: pollinators, disperser frugivores, insectivores, and vampires. The educational material used is a production of PCMM. From the second workshop year on, an evaluation is conducted to assess the children's acquisition of knowledge. These activities are developed jointly with governmental and private organizations. In 2006, we reached 530 students from 15 rural and urban schools. As a result of our research efforts, we have identified two new species records for Costa Rica, have developed roost ecology and behavioral studies, and are generating detailed maps of species distribution for the country. In addition we have constituted an Association, and are funding ourselves through donations and the activities of educational ecotourism associated with private organizations such as La Tirimbina Biological Reserve. As a short-term goal, we are writing a new children's book using a Central American approach. The book is entitled "Albita," the main character of which is the white bat (*Ectophylla alba*), and deals with roost selection conflicts.

Of White Architects: Tent Building Patterns and Process in *Ectophylla alba*

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Twenty-two species of bats around the world have been recorded using modified leaves as roosts, usually called "tents." It has been suggested that the mating system of tent-making bats is polygamy, based on the defense of a resource—tents. The hypothetical pattern in the literature is that males modify leaves to create a roost, so that females would select a male based upon some characteristics of a tent that potentially can be defended against other males. We tested this idea with *Ectophylla alba*, asking if males build the tents as defendable resources to attract females; we also asked how is the tent constructed and how often do they build one. We worked in Tirimbina Biological Reserve (Sarapiquí, Heredia). In 9 ha of forest, we counted the number of new tents each week for a total of 53 weeks, from July 2005 to August 2006. We expected the highest number of new tents to be found during the mating season. We also conducted searches for leaves recently modified with new cuts suggesting they were being modified, and every time we found a partly built tent we installed a VCR recorded under that tent to document the construction process at night, using infrared lights. The number of tents found per week had no relation to the mating season. Both males and females built tents. Bats used teeth and thumb claws to make the cuts. The average longevity of modified leaves as tents was variable (7.5 + 5 weeks). We present the first observations on a microchiropteran bat actively building a tent. We know that several individuals of both sexes participate in the construction of the tent. Our data on *E. alba* suggest that, at least for this species, tents are not used by males to attract/control females. Tent building apparently is a costly process, and the use of tents seems to be maximized to optimize the effort invested in construction.

The Impact of Social Organization on Genetic Structure

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The impact of social organization on genetic structure across small to medium spatial scales, where gene dynamics may critically shape evolution, is poorly understood. We examined genetic structure based on microsatellite markers in bat species from the genera *Rhinolophus* and *Kerivoula*, all of which are co-distributed in ancient forest. This study was designed to ameliorate several problems that often complicate the interpretation of genetic patterns. In particular, the study site in Peninsular Malaysia has been exceptionally buffered from radical habitat shifts. We tested for isolation-by-distance and spatial genetic spatial autocorrelation, and compared trends among species that exhibit different social structures and roosting ecology. Our early results indicated that genetic spatial autocorrelation was highest in species that roost in small groups. By comparison, no evidence of elevated relatedness among closely captured individuals was found in either a solitary species or in two congeneric species that roost in caves in large colonies. We discuss our findings with respect to the influence of behavioral traits on gene flow, as well as the consequences of these behaviors for genetic subdivision following habitat fragmentation.

Recurrent Replacement of mtDNA and Cryptic Hybridization between Two Sibling Bat Species, *Myotis myotis* and *Myotis blythii*

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With more than 1,000 species roaming in the nights of the world, bats are one of the most diverse groups of mammals. However, unlike other speciose groups such as orchids or wildfowl, hybridization is almost unknown among species of bats. By using a combination of highly variable molecular markers, we show that hybridization does occur between the Lesser Mouse-eared Myotis, *Myotis blythii*, and the Greater Mouse-eared Myotis, *M. myotis*. But even more intriguing, we found that both species share an almost identical mitochondrial DNA genome (much as if they were a single species), while their nuclear genome (and thus species identity) is apparently maintained distinct by strong selection against hybrids. We suggest that these contradictory patterns result from the early range expansion of Asian *M. blythii* into the range of European *M. myotis*, whereby the colonizing species have "sipped" the mitochondrial genome of the resident species throughout repetitive and asymmetric hybridization events. Such discordant results obtained with two classes of molecular markers warrant further scrutiny in the interpretation of patterns of gene flow deduced from mitochondrial DNA only.

Integrating Phylogenetic, Coalescent, and Population Genetic Approaches to Reconstruct the Historical Biogeography of *Triaenops*

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Phylogenetic methods in combination with divergence time estimation can reveal biogeographic centers of origin, differentiate between hypotheses of vicariance and dispersal, and reveal the directionality of dispersal events. Despite their power, however, phylogenetic methods can sometimes yield patterns that are compatible with multiple equally well-supported biogeographic hypotheses. Here, we use a synthetic approach that draws upon the analytical strengths of coalescent and population genetic methods to augment phylogenetic analyses in order to assess the biogeographic history of Madagascar's *Triaenops* bats. Phylogenetic analyses of mitochondrial DNA sequence data for Malagasy and east African *Triaenops* reveal a pattern that equally supports two competing hypotheses. Although the phylogeny cannot determine whether Africa or Madagascar was the center of origin for the species investigated, it serves as the essential backbone for the application of coalescent and population genetic methods. From a judicious application of coalescent and population genetic methods in an explicit hypothesis-testing framework, we conclude that a hypothesis of two independent but unidirectional dispersal events from Africa to Madagascar is best supported by the data.

Sex Differences in Population Genetics, Home Range Size, and Habitat Use of the Parti-colored Bat (*Vespertilio murinus*, Linnaeus 1758) and their Consequences for Conservation
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When habitats are declining, niche segregation by demographic groups, such as the two sexes, can have a profound impact on the extinction risk of a species as a whole. Thus, differences in the requirements of demographic groups are of importance in conservation. We combined behavioral and genetic data to investigate whether the sexually segregated particolored bat (*Vespertilio murinus*) exhibits sex-specific niche partitioning. We use our data to evaluate implications for conservation of this potentially vulnerable species in Switzerland, the western boundary of its range. Using radiotelemetry, we found sex-specific differences in habitat use. Foraging females strongly relied on lakes while foraging males displayed more flexibility in their habitat use. Moreover, males covered significantly larger foraging areas than females. Sequencing 341 base pairs of the mitochondrial D-loop of 247 individuals revealed sex-specific differences in the genetic structure of colonies but no such difference was observed for three nuclear microsatellite markers. We found high mtDNA diversity in two Swiss male colonies and one German female colony but low mtDNA diversity in two Swiss female colonies. Our genetic data suggest that considerable gene flow occurs via mating. At the same time immigration of females into the existing female colonies in Switzerland is rare compared to the immigration of new males into male colonies. Because we found the sexes in *Vespertilio murinus* to differ markedly in their ecology, population genetics, and behavior, we conclude that sex-specific conservation plans are required to protect this species efficiently.

Correlated Evolution Between Mating Systems and Roosts in Tent Roosting Bats
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Worldwide there are at least 19 bat species from 3 families that construct roosts by altering foliage, thereby creating a refuge called a tent. Tent-making bats utilize a wide variety of plants to construct their tents and they are known to use eight different architecture types, depending on shape, size, number of veins, or part of the plant modified. Most social interactions are performed inside the tent. Tent-making bats are known to be polygynous and exhibit seasonal single male-multi-female groups, year-round harem with less stable female composition, year-round multi-male multi-female with less stable females, and year-round harem with stable female composition. To date there has been no effort to explain reasons for variation in mating systems among species. We propose that some possible causes explaining variation in mating systems are phylogenetic relationships among species, roost persistence, or body size. To address this we used the bat supertree (Jones et al., 2005). Also we used the proposed mating system classification (McCracken and Wilkinson, 2000) to create three binary categorical characters: 1) female fidelity; 2) group seasonality; and 3) male presence in the group. Roosts were classified as those lasting less than a season or those lasting one season or more. We included 71 species for which mating systems and body size were available to trace the evolution of characters on the tree using the software Mesquite. To test for correlations in character evolution, we used Pagel's method to compare between two categorical characters and the pairwise comparisons method to compare between one continuous and one categorical character. These comparisons allowed us to determine the distribution of mating systems and roosts types in the phylogeny and how other traits have influenced the evolution of mating systems. The results obtained here represent the first attempt to evaluate the possible causes of divergence of mating systems in tent-making bats.

Preliminary Results on Habitat Selection and Spatial Ecology by the Mehelyi's Horseshoe Bat (*Rhinolophus mehelyi* Matschie, 1901) in Contrasting Landscapes
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The Mehelyi's horseshoe bat (*Rhinolophus mehelyi*) is a medium-sized bat, and is one of the five rhinolophid species occurring in Europe. The only published radio-tracking study—carried out in southern Spain—proposed a semi-natural loose oak woodland, known as 'dehesa,' as an important habitat for the species, although the high inter-individual variability in use precluded drawing general conclusions for the preference of this species. In order to get a clearer picture of its habitat preferences, we radio-tracked individuals at two underground colonies in southern Spain with contrasting habitat availability: Las Marías—LM, a female breeding colony; and La Aurora—LA, a male aggregation colony during breeding period. Foraging home ranges ranged from 2–224 ha in LM and from 10–967 ha in LA. The maximum distance traveled from the roost in a single night by one bat was 13 km for both roosts, but average distance traveled was 6.8 km for LM and 8.2 km for LA. In LM the first habitat in ranking preference was the dehesa, but there was no significant difference with the second ranked habitat type: *Eucalyptus* sp. plantations. This contrasts sharply with the results obtained in LA, where riparian woods were significantly the most preferred habitat, and the second habitat type in preference order was the broadleaved woodland. This lack of consistency could not be explained by a different abundance of potential competitors in LA and LM, since it was negligible at both sites. So then, do males and females have different habitat preferences? Did differences in prey abundance across habitat categories drive habitat selection? Or did undetected spatial features, i.e., other than habitat categories extracted from land use maps, affect the distribution of foraging bats?

Community Dynamics of Bats at La Selva Biological Station, Costa Rica: 1973 and 2005
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Many authors have emphasized the great importance of making long-term studies of changes in community structure in order to better understand the factors that determine changes in the community over time. However, our knowledge of Neotropical bat communities, dynamics, and species richness is still very limited. La Selva Biological Station (OTS) in Costa Rica has been studied for more than 40 years. A detailed study of the bat community structure was published 30 years ago. This greatly facilitates long-term studies of the La Selva bat community. Our principal aim is to compare the present bat community parameters in La Selva with the ones observed in the first study 33 years ago. To facilitate the comparison, we used the same sites, methods, and capture efforts reported by LaVal and Fitch. We found that the community structure (Morisita similarity index 0.876), diversity (Simpson Index 6.114 vs. 6.844), richness (35 vs. 36 species), and trophic guilds were very similar in both studies. However, bat captures decreased 30% in 2005 compared to 1973. This pattern of decreased captures has been observed in other taxa at La Selva, including birds, leaf litter frogs and lizards, snakes, and rodents. Different causes depending on the group have been proposed. For bats, we propose two different kinds of effects that could explain the reduction in captures: 1) external factors—deforestation of the surrounding area and the growth of large plantations (especially pineapple and banana); and 2) internal factors—maturation of the forest and changes in roost availability.

Economic Assessment of the Ecological Service Provided by *Tadarida brasiliensis* as a Pest Control Agent in Nuevo Leon, Mexico: A First Approach

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In spite of being within the limits of a State Protected Area “Sierra Cerro de la Silla” in Santiago, N. L., Mexico, and having been proposed as a core area in the management plan, La Boca Cave suffers a high level of vulnerability due to its location next to a busy highway. The objective of the study was to determine the economic value of the environmental service that the Mexican free-tailed bat (*Tadarida brasiliensis)* population—which inhabits the cave—provides as a natural pest control agent in the region. Results could be useful as a conservation tool to support protection of the bat population itself as well as the ecosystems of which they are a part. This includes their roosting site and the surrounding area with all the environmental services they provide. The study is based on this bat’s food habits. The insects identified in their diet were compared to agricultural pests as reported by official sources and interviews with local producers. According to primary and secondary information on the economic importance of sorghum, maize, citric, and pecan crops on the influence zone, and to the intensity of the chemical products used to control pests, it is estimated that the economic value of the ecological service provided by the bats ranges between $6.5 and $16.5 million Pesos per year (between 0.6 and 1.54 million USD per year). This amount will increase as we incorporate the results of our ongoing economical analysis for tomato and other crops.

Effects of Season, Weather, Moonlight, and Insect Activity on Bat Activity in the City of Adelaide, South Australia

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Insectivorous bats are among the few native mammalian taxa that persist in Australia’s urban environments, yet little information is available on the ecology of the bats that occur in urban areas, including the city of Adelaide. We used echolocation call detectors to assess bat activity among different sites in the Adelaide City parklands in response to season, weather, moonlight, and insect availability. Malaise traps and light traps were used to assess insect availability in relation to artificial lights and weather. We identified at least six insectivorous bat species using the City’s parklands. Bat activity fluctuated among sites and seasons; rainfall and moonlight limited bat activity, and both bat activity and insect biomass increased with temperature, with a burst in activity occurring from around 12˚C. No bat was recorded in bat boxes or potential tree roosts in Adelaide; minimal bat activity was recorded in the first two hours after civil twilight, so bats may roost outside the city and migrate nightly into parkland areas to forage. Opportunistic species *Chalinolobus gouldii* and *Mormopterus planiceps* (species 4) were most advantaged in Adelaide’s parklands and overall low levels of activity recorded from *Vespadelus* species, *Tadarida australis*, and *C. morio* should prioritize them for conservation by the Adelaide City parkland managers.

Identification of Bats on Puerto Rico Using the Scanning Electron Microscope to Examine External Hair Morphology

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Puerto Rico, the easternmost island in the Greater Antilles, is home to 13 species of Chiroptera, representing five families—Molossidae, Mormoopidae, Noctilionidae, Phyllostomidae, and Vespertilionidae. The purpose of this study was to determine whether individual species found on Puerto Rico could be identified based on external hair morphology, as seen under the scanning electron microscope. Hair samples were taken from the dorsal mid-scapular region of one to four bats of each species. For consistency and repeatability, we chose to examine the area between 550 and 800 μm from the hair tip for all samples; however, an additional segment between 120 and 200 μm from the tip was needed to differentiate two species in the Phyllostomidae. Each of the 13 species demonstrated distinct morphological hair characteristics that allowed identification based on hair alone. Practical uses of this technique would be to identify hair samples taken from archaeological sites or to determine which species of bat once occupied now-abandoned roosts. In addition, analysis of hair found in owl pellets or the feces of mammalian carnivores, such as feral cats, could be used to examine predator-prey interactions, even if no identifiable skeletal remains were present. Cost of operating a scanning electron microscope has declined over the last two decades, and the introduction of digital photography has made the technique more time efficient. We suggest that examination of hair under the scanning electron microscope could help differentiate among species in other simple assemblages of bats, such as those on different islands or restricted areas of continents, and perhaps use of this technique as a broader taxonomic tool should be revisited.

Impact of Traffic Noise on Bats

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Bats live in an acoustic world; they use echolocation to orient in space. Many gleaning bats listen for prey-generated rustling sounds to find insects on vegetation or the ground, where prey is concealed from echolocation by overlapping strong background echoes. Listening for the relatively faint prey sounds might be impaired by natural or anthropogenic background noise. Here we: 1) tested whether bats avoid noise and 2) quantified the impact of traffic noise on their foraging success, using the greater mouse-eared bat (*Myotis myotis*) as a model species. It occurs in central and southern Europe, is very mobile, and has high conservation priority. Therefore its potential vulnerability to traffic noise is directly relevant for most highway planning in Europe. In a choice experiment, the bats avoided foraging under continuous broadband noise and, to a lesser extent, also under transient traffic noise. In a detection experiment, the bats had to find prey under playback of continuous traffic noise corresponding to different highway distances (7.5 m, 15 m, 25 m, 35 m, 50 m, and silence as a control). The bats' detection performance was high above chance level under all noise levels. However, compared to the control condition, the performance within a 1-min-time-window was significantly reduced under noise levels corresponding to highway distances of up to 35 m. Search time was 4 times longer under noise levels of 7.5 m and still 1.5 times longer for 50 m than under control condition. The increase in search time is presumably linked to a reduced detection distance, which in the field will translate into reduced search efficiency. Taken together, our data show that gleaning bats avoid loud broadband noise and that foraging by listening for prey sounds is affected by traffic noise up to highway distances of at least 35 to 50 m.

How Bats Communicate Aggression

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Social interactions in bats are frequently accompanied by vocalizations of situation-specific physical structure. The present paper focuses on the role of vocal communication during agonistic encounters. In the Indian False Vampire Bat, *Megaderma lyra*, three distinct call types (aggression calls, whistles, and response calls) occur in agonistic interactions. We analyzed agonistic approach situations to assess the extent to which these calls reflect the specific part of the caller in the interaction and the intensity of the agonistic display. A frame-by-frame video analysis followed by a multiparametric sound analysis revealed that call type indicated the part of the respective caller while interaction intensity was encoded in systematic changes of call sequence parameters. For aggression and response calls, total call duration, the number of call elements, and the number of calls within a sequence increased, while intervals between call elements decreased with interaction intensity. Moreover, the frequency of response calls was increased at higher interaction intensity. These results correspond to acoustic correlates of changes in affect intensity in primates and emotional prosody in human speech. At present, we analyze data of a playback study based on a habituation-dishabituation paradigm to evaluate the ability of the bats to categorize the above changes in call structure on the basis of acoustical cues alone. This experiment will reveal whether emotional prosody is perceived by bats and may thus be considered a basic feature of animal communication dating far back in the evolution of mammals. [Supported by DFG Schmidt879/6-3.]

The Intake Responses of Three Species of Leaf-nosed Neotropical Bats

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We investigated the intake response to sugar concentration in food of three Neotropical bat species: *Leptonycteris curasoae*, *Glossophaga soricina*, and *Artibeus jamaicensis*. We also evaluated how both a seasonal change in minimum temperature and physiological constraints affected the intake responses of *G. soricina*. Our experiments were conducted in outdoor enclosures (2x5 m) located in the tropical dry-forest of Chamela, Mexico. We measured food intake at various concentrations of sucrose or 1:1 mixtures of glucose-fructose (292, 438, 584, 730, 876, and 1022 sucrose equivalents). Our results show that physiological mechanisms limit food intake in the three species of bats. Bats did not show differences in the intake between sucrose and the 1:1 glucose-fructose solutions, indicating that digestion and absorption in bat intestines are paired. Our results suggest that, on the basis of energy intake, bats should not prefer hexoses to sucrose. Seasonality affected both the intake response and food intake rate of bats. Differences in energy expenditure between the wet/warm and dry/cool seasons may account for the differences we observed. Using the rate of sucrose hydrolysis and the small intestinal

volume of bats, we modelled their intake responses. During both seasons, the predicted maximum intake rates from our model were generally higher than the intake rates we observed. Additionally, our model predicts "broken" intake responses when the metabolic expenditures of bats are increased above 50 kJ d^{-1}. A physiological constraint on the rate of food intake may explain the geographic distribution of *G. soricina*.

Immunology of Virus Persistence in Bats

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Bats have recently gained substantial attention as reservoirs or potential reservoirs of several human pathogenic viruses, including SARS coronavirus, Nipah virus, Hendra virus, Ebola viruses, and Marburg virus. Recent work has suggested that bats are the likely principal reservoirs and original hosts of coronaviruses, including as many as three novel North American coronaviruses. Although many of these viruses cause disease in humans, their infections in reservoir host bat species appears to be innocuous. Of particular interest to us is that infection in bats leads to high-titered immunoglobulin-G (IgG) antibody responses, yet these responses apparently fail to clear the viruses. The presence of this antibody indicates that bat T cells are participating in the response but are unable to mediate a sterilizing immune response. We have therefore initiated a project to understand bat T cell responses, particularly the cytokines produced by these T cells that result in antiviral activities. We have cloned several bat cytokine genes from Seba's Short-tailed Fruit Bat (*Carollia perspicillata*) and the Jamaican Fruit Bat (*Artibeus jamaicensis*) as an initial step in developing these species as models of bat-virus reservoirs. We are also developing in vitro methods of propagating virus-specific bat T cells with the hope of understanding why bats are unable to clear these innocuous infections. Understanding the ecology of these viral infections may help devise novel methods for minimizing human impact on bats, as well as suggest therapies for treating human diseases caused by bat-hosted viruses.

Flying Foxes, Farmers, and Fruit Crops: Novel Solutions for Old Problems

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Highly mobile and colonial roosting flying foxes (*Pteropus* species) interact with people in urban and agricultural environments, presenting challenges for conservation and management. Since Europeans settled in Australia 200 years ago, farmers growing a range of exotic fruits have attempted to manage flying foxes feeding in orchards at night by shooting them in the act, as well as by targeting daytime camps in an effort to either cull or relocate animals that are perceived to be 'resident' in the local area, and therefore, responsible for orchard visits. Such efforts have largely been unsuccessful, and further fuelled the frustration associated with defending fruit crops against these nocturnal "raiders." More recently, lethal electric grids were used widely at fruit orchards in the States of New South Wales and Queensland, until the Commonwealth Government outlawed this controversial practice in 2002. Best estimates are that flying fox damage to fruit crops costs the Australian production industry in excess of $20 million annually, and yet affordable non-lethal means of mitigating flying fox crop damage remain elusive; fully netting orchards appears to be the only sustainable solution, but the outlay cost is too high for many farmers. Here we present landscape-scale *Pteropus conspicillatus* population data collected each month over three years, along with findings from our comprehensive survey of Far North Queensland farmers. Continual variation in *P. conspicillatus* roost-site occupancy and camp size indicates that attempts to manage flying foxes at the local level are inherently ineffective. Novel solutions for flying fox conservation hand-in-hand with viable grower livelihoods are needed.

A Role for Echolocation Ability in Resource Partitioning?

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A number of studies on closely related species have identified morphological differences that lead to differentiation in their mechanical access to food; e.g., the classic case of Darwin's finches with differently sized and shaped beaks. Less attention has been paid to interspecific differences in the senses used by animals to detect food and their role in promoting resource partitioning. It is well known that bats from different foraging guilds (e.g., open space bats versus narrow space bats) differ in both flight morphology and echolocation behavior. If, however, a given prey type is easily detectable by one predator species but not by another, this would lead to the same prey being differentially available even if the two predators foraged in the same microhabitat. We will review recent evidence suggesting that indeed sensory specialization might play a role for niche differentiation within closely related bat species from the same foraging guilds. Using European *Myotis* and *Rhinolophus* species assemblages as model systems, we combine acoustic, behavioral, and ecological data to test the hypothesis that differences in sensory performance result in differential access to prey types for closely related bat species. We will present a modelling approach to assess the constraints under which differential sensory access to prey can evolve and stabilize the coexistence of species.

Echoacoustic Adaptations of Chiropterophilous Flowers

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Pollination by animals provides great advantages for plants and is discussed to be one of the main reasons for the evolutionary success of angiosperm plants. To use these advantages plants have to attract and reward their pollinators. This is done in manifold ways, adapted to the preferences and the sensory capabilities of their pollinators. Bat pollinated plants also pulled out all the stops to attract their nocturnal pollinators and developed signals echoacoustically conspicuous for their pollinators. To investigate the abundance of echoacoustic signals in bat pollinated plant species, we developed a mobile apparatus to conduct ultrasound echo measurements in the field. We found two species of flowers that have remarkable echoacoustic adaptations. Both plant species (out of two different families, Fabaceae and Marcgraviaceae) have developed independently a reflecting structure acting like an "acoustic cat eye," reflecting most of the energy of a bat call back to the sender, over a wide range of angles of sound incidence. In addition the echoes show distinct structures in the time and in the spectral domain. These kinds of echo signals might be rare, but nevertheless, the echoes of many bat flowers have echo features that probably allow the approaching bat to localize position and orientation of the flower, and therefore, provide information to guide their pollinators precisely to the nectar chamber.

Morphological Character Evolution in the Genus *Dermanura* (Phyllostomidae: Stenodermatinae)

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Diversity of *Dermanura* Gervais 1855 has been a matter of debate among researchers, with the number of recognized species ranging from only one (*cinerea*) to nine (*anderseni*, *azteca*, *cinerea*, *glauca*, *gnoma*, *incomitata*, *phaeotis*, *tolteca*, and *watsoni*). Ongoing phylogenetic analyses of cytochrome *b* sequences suggest at least 12 monophyletic phylogroups. Morphological studies of voucher specimens with genetic data allow diagnosing each clade and restricting use of available names. Thus, in addition to the nine above, we recognize *bogotensis*, *rava*, and *rosenbergi* as distinct and valid species within *Dermanura*, which now includes 12 species. To complement these analyses, we identified and scored 22 morphological characters for *Dermanura* and the outgroup (*Artibeus* and *Koopmania*). Preliminary comparisons of resulting topologies based on these datasets do not show full agreement on the diversification (branching) pattern within *Dermanura*. Here, we used the most resolved and supported molecular topology to map these morphological characters and to identify consistency of taxonomic variation. Overall optimization of these characters can reveal possible pathways leading to monophyletic clades identified in the molecular topology. For example, a parsimonious explanation for the variation in the number of lower molars is that the ancestor had only two, with the third lower molar appearing independently in the clades [*rosenbergi* + *watsoni* + *incomitata*] and [*glauca* + *gnoma* + *bogotensis*], but then being lost in one species (*bogotensis*).

Breeding Behavior of *Leptonycteris yerbabuenae* (Phyllostomidae: Glossophaginae): Female Choice or Male Power?

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Information on mating systems exists for only 66 of the 1,100 bat species known. Similar to other mammals most of them are polygynous. Multi-male, multi-female groups have been reported for only 16 species. We observed copulations of *Leptonycteris yerbabuenae* in a cave housing approximately 30,000 individuals on Isla Don Panchito, Jalisco, Mexico. Reproductive males were found in a lek-type organization away from the main roosting group. Agonist interactions were frequently observed between reproductive males that defended small roosting territories around them allowing space for females to land. Males repeatedly licked their back foot and then scratched their genital area, finally transferring genital secretions to the middle of their back by scratching the interscapular zone with their foot. This process resulted in a strongly scented dorsal patch. Females repeatedly hovered in front of males often flying up to “evaluate” and touch the dorsal patch with their nose. Upon selecting a male, females placed their ventral surface against the males´ back and hung from the back of the male caressing the dorsal patch. Two types of copulatory behavior were observed. In-pair mating occurred when a male initiated copulation with a female that was hanging on his back. When completed the female remained with the male returning to his back. Extra-pair copulations occurred when males grabbed nearby females and forced copulation. This behavior was not preceded by any physical contact between the two individuals and the female departed immediately after copulation. The proportion of forced copulations observed in *L. yerbabuenae* (69.9 ± 5.1%) represents the first documented case of recurrent forced copulations in mammals. In this species, sexual coercion appears to be more important than female choice, but genetic paternity studies are needed to further evaluate this hypothesis.

Effects of Sugar Composition and Concentration on Food Selection by Saussure's Long-nosed Bat (*Leptonycteris curasoae*) and the Long-tongued Bat (*Glossophaga soricina*)
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In the Neotropics, bat-pollinated plants secrete relatively dilute nectars dominated by hexoses, glucose, and fructose with only small amounts of sucrose. We investigated the concentration and sugar composition preferences of Saussure's long-nosed bat (*Leptonycteris curasoae*) and the long-tongued bat (*Glossophaga soricina*) to test the hypothesis that bats prefer the predominant characteristics (sugar composition and concentration) found in their natural diets. We offered bats pairs of test diets in large outdoor enclosures that allowed free flying. We used artificial nectars that simulated compositions and concentrations found in flowers visited by these two species at the study site. Contrary to our predictions, bats showed no preference between sugar types when test solutions had the same concentration. However, *L. curasoae* preferred concentrated over dilute solutions independent of sugar type. Only one preference for concentrated over dilute solutions was recorded for *G. soricina*. Both bat species appeared to perceive sugar types as energetically equivalent in most trials. Our study rejects the hypothesis that nectar-feeding Neotropical bats act as a selective pressure on nectar composition in chiropterophilous plants. Other possible explanations for the predominance of hexose in chiropterophilous flowers need to be evaluated.

Ecological and Evolutionary Correlates of Cross-species Rabies Transmission among Bats
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Bats are an increasingly recognized source of lethal human viruses, including Nipah virus, Hendra virus, a variety of rabies-related lyssaviruses and potentially SARS-CoV and Ebola. Implicit in the emergence of bat-associated viruses is the concept of disease transmission between species; however, almost nothing is known of the frequency or ecological drivers of cross-species transmission (CST) in natural bat communities. Many North American bat species maintain phylogenetically distinct lineages of rabies virus, allowing quantification of transmission within and between species through molecular epidemiology. Here, we combine such epidemiological data with comparative analyses to explore how the ecological and evolutionary characteristics of different bats contribute to patterns of disease transmission. Preliminary results show that rates of CST vary widely among bat species and were associated with ecological characteristics of hosts, including roosting behavior and wing morphology. In contrast, the direction of CST between species pairs, or 'who infects whom?', was influenced by both the pairwise genetic relatedness of species and their degree of geographical range overlap. Transmission rates were highest between closely related bats, but were also elevated between distant relatives that share a large portion of their geographic range. Our results demonstrate that ecological differences among bats influence the epidemiological patterns of their pathogens and suggest that underlying ecological and genetic variables may guide predictions of disease transmission between species.

A Comparison of Roost-tree Selection Between Three Species of *Myotis* Living in Syntopy

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Northern long-eared bats (*Myotis septentrionalis*), Indiana bats (*M. sodalis*), and little brown bats (*M. lucifugus*) are uncommon species in the Great Lakes region of North America and coexist at few locations. During summer 2006–2007, we radio-tracked northern long-eared bats, Indiana bats, and little brown bats to roost structures in southeast Michigan, U.S.A., in an area that contains one of the largest remaining patches of contiguous forest in an area dominated by agriculture. Preliminary examination of data indicates that both northern bats and Indiana bats tend to select roost trees of a greater diameter than the median available at a 0.1-ha spatial scale. Diameters of trees selected by Indiana bats were not significantly different from those utilized by northern long-eared bats. In general, northern long-eared bats tended to be more plastic in their roosting preferences than Indiana bats, utilizing a wider range of tree species in various stages of decay. Little brown bats roosted almost exclusively in man-made structures (buildings, bridges, etc.).

Habitat Fragmentation and Infectious Disease Dynamics in Bat Communities in Mexico

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Habitat fragmentation and biodiversity loss are associated with increased disease transmission rates in birds and non-volant mammals. However, little is known about infectious dynamics in bat communities. We discuss future perspectives that combine macroecological and microecological approaches on infection dynamics in bat species assemblages in fragmented landscapes in México. There are 139 species of bats that live in Mexico, which represents over 30% of mammal species locally and over 10% of the global number of bat species. However, increasing habitat loss and fragmentation affect bats in several ways. Bats are sensitive to habitat fragmentation that has caused diverse changes in species assemblages in bat communities, diversity loss, and very likely also changes in distribution patterns for reservoirs. We predicted different outcomes in infectious disease dynamics in a changing landscape due to agriculture including: 1) increasing distribution range of opportunistic species including frugivores and vampire bats such as *Desmodus rotundus* with increasing fragmentation; 2) expansion of rabies outbreaks is predicted to occur in fragmented landscapes where cattle range is expanding; and 3) pristine areas with high diversity of bats will have a high diversity of parasites and infectious agents, but the prevalence in bat populations will be buffered, compared to fragmented areas. We see a critical need for further research into the extent to which habitat fragmentation influences infectious disease dynamics in bat communities. Comparative community studies of bats are crucial for a better understanding of how landscape changes are influencing species assemblages and infectious disease dynamics. Landscape and community ecology approaches will provide a better understanding on the dynamics of vectors and reservoirs and will have great implications

in the control and management of zoonotic diseases. Habitat conservation at the landscape scale should be a huge asset to prevent additional emerging disease outbreaks.

Computational Fluid Dynamics Approaches for the Study of Bat Flight
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To understand the nature of the aerodynamic forces that enable bat flight, we must understand some of the complexity of the three-dimensional airflow around deformable flapping wings. Bats represent a complex system of coupled solid mechanics and fluid dynamics. Computational aero-elastic approaches are one set of methodologies the bat research community has yet to fully explore. These approaches take large, temporally and spatially complex processes, which are often governed by systems of partial differential equations, and break them down into many, sometimes literally millions, of simpler solvable problems linked together by various sets physical of rules. Although all such approaches make simplifying assumptions, they can be experimentally validated, and often allow investigators to explore otherwise inaccessible phenomena. For example, a validated model of a particular bat flying over a given range of velocities might be employed to better understand the role of particular features of bat flight kinematics, such as bats' greater use of fore-aft wing motions than is seen in bird or insect flight. Ultimately, these models could be used to probe the characteristics of the same bat flying at a much higher speed, thereby helping to identify factors that limit top flight speed, or morphologies of extinct bat ancestors can be placed into validated models to determine likely flight characteristics of fossil or hypothetical forms. Selecting appropriate models for bat flight involves many considerations, such as determining the level of kinematic and tissue materials data needed for adequate resolution, identifying the most relevant fluids modeling approaches for particular bat flight phenomena, and assessing computational power needed to arrive at various simulations. An additional possibility is to determine where flight efficiency in bats can be improved to help identify physical, morphological, or other constraints on bat flight.

Training Bats to Avoid Wind Turbines Using an Acoustic Deterrent
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The documented bat mortality at wind energy facilities elevates concern for bat populations when extrapolated out to the number of proposed installations, particularly those crossing corridors used by migrating bats. During the 2006 field season we tested a prototype acoustic deterrent by monitoring foraging activity at eight different pond sites in California and Oregon for two nights to establish baseline activity levels; then after observing activity similar to baseline on a third night we activated the ultrasonic sound regime. We measured activity in the same way each night by counting visual passes of bats entering and leaving the recorded view from a Sony DCR-TRV520 Nightshot video camera equipped with a high intensity, infrared lamp. For the same one-hour period each night the mean baseline activity was 419 ± 153 passes, compared to 238 ± 88 passes with the ultrasound regime active, $p \leq 0.025$. We concluded that ultrasonic broadcasts have promise as a tool for deterring bats from approaching turbines. During the 2007 field season we are testing the longer-term effects of the acoustic regime to determine whether bats will accommodate it or learn to avoid it. We will present the results of this current investigation.

Strange Things Done in the Midnight Sun: Bats at High Latitudes
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Little is known about the distribution and ecology of northern temperate bat populations, especially in the Nearctic. Bats at high latitudes are of interest because they are exclusively nocturnal yet they exist in an environment where hours of darkness are limited in the summer. How do bats in northern Canada adjust their foraging behavior to conditions involving short nights, and short cold breeding seasons? I assessed bat activity and habitat use, using bat detectors, in six different habitat types from 1 May to 20 August 2006 and in two different habitat types from 1 June to 30 June 2007 in Watson Lake, Yukon (60° 06' N, 128° 46' W) in the vicinity of a little brown bat (*Myotis lucifugus*) maternity colony. Preliminary results indicate that little brown bats in the Yukon are limited by night length and thus have a restricted nocturnal foraging period near summer Solstice. They tend to forage in more protected environments such as the interior of forest stands and over flowing water near summer Solstice when light intensity is high, and in more exposed environments such as forest edges during darker nights. Bats shift their habitat use over the summer most likely because of changes in light intensity; however, insect abundance and distribution may also be contributing factors. Analyses of diet and prey abundance and distribution will help determine this.

The Biogeographic Origin of Bats: Africa or America?
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The evolutionary history and biogeographic origin of the order Chiroptera is rife with conflicting hypotheses due to competing phylogenetic trees and a poor fossil record. However, recent large molecular data sets (exons, introns, and mitochondrial data) have provided conclusive, congruent support for the paraphyly of Microchiroptera and for the phylogenetic position of most families. Currently, the phylogenetic positions of Miniopteridae, Craseonycteridae, and Myzopodidae are still in dispute due to inadequate data and conflicting results. To resolve the phylogenetic positions for these families, a combined nuclear supermatrix (~15 kb, nuclear introns and exons) was generated, collected, and analyzed using traditional phylogenetic techniques. This new phylogeny was used to elucidate the biogeographic origin of bats and the resulting four superfamilial microbat clades. Both the 'Out-of-Africa' and Laurasiatherian hypotheses for the origin of bats were assessed using evolutionary biogeographic reconstruction methods. These theories were further investigated in light of recent fossil evidence.

Origins of Diverse Cave-Bat Faunas: The History and Ecology of Natalid Biogeography
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Diverse cave-bat faunas differ in taxonomic composition throughout the Neotropics. The cave-dwelling lineages Natalidae and Mormoopidae are best represented toward the north of the region, whereas Lonchophyllinae and Phyllostominae are best represented toward the south. Can this pattern be explained by ecology or by history? An analysis of the family Natalidae points to both. Niche models and cave distribution data explain the absence of the family in permanently wet and caveless areas such as the northwestern and southwestern Amazon basin quadrants but not in apparently suitable areas such as the western Amazon dry forests and Puerto Rico. An analysis of natalid biogeographic history, based on a combined morphological/molecular phylogeny, reveals that absence of these bats from suitable regions is due to the isolation of these areas from the dispersal corridors followed by the family during its evolutionary history. These results highlight the combined effect of history and ecology in producing spatial taxonomic turnover over seemingly uniform or continuous environments.

The Genetic Structure of a Population of the Chocolate Wattled Bat, *Chalinolobus morio* in Southeastern Queensland, Australia: Preliminary Results from mtDNA Analysis

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Aspects of the breeding biology of the Chocolate Wattled Bat (*Chalinolobus morio*) were examined in the Bunya Mountains region of southeastern Queensland, Australia using nucleotide sequences of the mitochondrial DNA D-loop from a maternal colony (n = 72). This species is unusual amongst microchiropteran bats in that males closely associate with maternity colonies, forming adjacent, segregated roosts. For comparison with this main colony, samples were also taken from a colony 75 km to the northeast (Colony 2, n = 7) and another, 130 km to the southeast (Colony 3, n = 9). DNA from tissue samples was extracted and amplified through PCR reactions and sequenced. The resultant 800–900 bp sequences were aligned in Sequencher® 4.5. As in previous mtDNA investigations of vespertilionid bats, sequence length heteroplasmy was evident in the hypervariable domain I, immediately upstream from the proline tRNA. An 81 bp motif in this region was found to be repeated 4 to 6 times. Thirty-seven percent of sequenced individuals were found to be heteroplasmic. Sampling of the Bunya Mountains colony revealed the presence of 26 mitochondrial haplotypes and of these, 24 have been identified only in this colony. The two other haplotypes were shared with Colony 3, and none were shared with Colony 2. Further sampling is required to explore genetic relationships; however, based on the material analyzed to date, differentiation between the colonies is evident. These results are not inconsistent with those obtained elsewhere for temperate vespertilionids where female philopatry has been identified. Results to date also indicate long-term gene flow between the main Bunya Mountains colony and Colony 3 but less exchange between the main colony and Colony 2, which is closer. Implications for the breeding system are discussed and an annual life history cycle is proposed.

Seasonal Variation in the Occurrence of Hoary Bats in Hawaii

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Seasonal movements across the island of Hawai`i by the endangered Hawaiian hoary bat are poorly understood. To test the hypothesis that hoary bats move seasonally across the island, we deployed arrays of automated ultrasound detectors for a minimum of seven nights at six sampling sites. We recorded bat detections and applied occupancy analysis to quantitatively estimate bat occurrence. Detector arrays were deployed along elevational gradients to examine seasonal patterns in occurrence on both dry leeward (western) and wet windward (eastern) sides

of Hawai`i Island. Recorded bat calls were processed with Analook and occupancy was estimated with Presence 2 software. Preliminary results indicate that bat occurrence was low in the windward lowlands during January through March with a dramatic increase in activity beginning in April. Bat activity was recorded in the windward highlands from January through April with a decrease in activity as spring approached. Detections were infrequent at dry high elevation sites. Bats were consistently present at moderate occupancy levels throughout our monitoring period on the lowland leeward site. We conclude that seasonal shifts in occupancy are occurring and we are continuing our monitoring program.

Biogeographical Patterns of the Mexican Chiroptera Fauna: A Regionalization Proposal
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We analyzed distributional patterns of 129 species of Mexican bats to identify general patterns that support a biogeographic regionalization based on flying mammals. We constructed minimum-spanning trees among known localities of each species, and a presence-absence matrix based on the areas of high vortex incidence. The matrix was analyzed by an UPGMA using Jaccard's similarity index. We identified 25 chiropterologic provinces, in two main branches: 1) Nearctic, which includes Baja California, Baja California Sur, Bolsón de Mapimí, Altiplano Norte, Altiplano Sur, Tamaulipeca, Sierra Madre Occidental and the Transmexican Volcanic Belt; and 2) Neotropical, which is subdivided into a) Caribbean (Petenes and Yucatan); and b) Mesoamerican (Soconusco, Altos de Chiapas-Tuxtlas, Veracruzan Coastal Plain, Tehuantepec, Sierras Norte de Chiapas, Chiconquiaco, Sierra Madre Oriental-Sierra Norte de Oaxaca, Colima-Jalisco Coastal Plain, Nayarit-Sinaloa Coastal Plain, Sierra Madre del Sur, Sierras and Valleys of Guerrero, Tehuantepec Isthmus Coastal Plain, southern Puebla and Selva Lacandona). An additional Cladistic Analysis of Distributions and Endemism (CADE) was performed, and in the consensus tree we found support for 21 of the provinces as identified by the UPGMA. Using bats allowed us to visualize a more detailed system of provinces, as compared to regions found using other animal taxa, recognizing previously unidentified areas as the Veracruz Coastal Plain, Tehuantepec, Guerrero Sierras and Valleys, among others, as well as redefinition of the Sierra Madre Oriental, and the division of the Yucatán Peninsula into the Petenes and Yucatan, and the Altiplano in northern and southern sections.

Generalization and Specialization in Flower-visiting Bats
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I present an overview to flower-visitation in Neotropical bats. Species from almost all subfamilies within the Neotropical bat family Phyllostomidae are known to obtain at least a part of their diet from flowers, including the Phyllostominae, Stenodermatinae, Carolliinae, and Glossophaginae. Although nectar is mainly used as a supplementary food within most of the subfamilies, in the Glossophaginae dependence on nectar is highest and the species show distinct adaptations to a nectar diet, such as elongated rostra and tongues and a specialized hovering flight. However, even among the glossophagines this dependence varies widely and some generalistic species are frequently reported among frugivores, while others rely almost entirely on floral resources and might be considered nectar specialists. From an ecological view the behavior of glossophagines presents a variety of interesting transitional situations. Some flowers visited by glossophagines are probably co-evolved with other pollinators and may show reduced fruit set when visited predominantly by glossophagines. Similarly, fruit handling behavior in more generalistic species differs drastically from “real” frugivores and seed dispersal capabilities seem to be comparably limited. Flexibility, driven by energetic necessities, allows especially the generalistic species to expand their feeding niches, and the resulting ecological interactions with plants are not always entirely mutualistic. These ecological interactions between glossophagines and their food plants emphasize that foraging behavior of phyllostomid bats is extremely plastic and that different feeding niches are often connected by transitional forms.

Taxonomical Position of the Genus *Eudiscopus* (Mammalia, Chiroptera) Among Vespertilionid Bats

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Eudiscopus (disk-footed bat) is a monotypic genus with complicated taxonomic history. Based on the presence of disk-like pads on foots and forearms, Tate (1942) placed *Eudiscopus* to Pipistrellini tribe along with the genera *Tylonycteris* and *Glischropus*. This point of view has been accepted until now, probably because of the rarity of samples in world collections. Our morphological and genetic analysis showed that only *Glischropus* is close to the genus *Pipistrellus*, while *Tylonycteris* is related to the genus *Vespertilio*, and *Eudiscopus* is close to the genus *Myotis*. External characters such as auricle and tragus shape, skull, and tooth characters of *Eudiscopus* resemble those of *Myotis*. Analysis of partial sequences (850 bp) of the cytochrome *b* gene also showed close relationships of the *Eudiscopus* and *Myotis* genera. Also *Myotis*, *Eudiscopus*, and *Murina* genera clustered together opposite *Pipistrellus* and *Eptesicus* genera in genetic analysis. These data are in agreement with those of Hoofer and Van Den Bussche (2003) and support the view that *Myotis* is a separate subfamily within Vespertilionidae. In this case *Eudiscopus* should be included into the subfamily as well.

Linking Landscape and Local Patterns of Rabies Virus Exposure and Immune Response in Brazilian Free-tailed Bats (*Tadarida brasiliensis*)

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Despite mounting evidence that bats are natural reservoirs to a diversity of viral pathogens, the immune systems of bats are poorly understood. We have reported evidence that both roost ecology and parasite pressure can alter the immune responses in wild colonies of bats. Moreover, past and current field surveillance indicates highly variable exposure to rabies virus across the geographic range of this species. Ecological and energetic drivers may interact synergistically to depress the immune responses of entire colonies of bats, increasing their susceptibility to transmission and development of clinical rabies infection. In highly gregarious colonies, compromised immune response and the seroprevalence to rabies virus tend to peak during lactation, suggesting that individuals may be sensitive to the energetic costs associated with weaning young and heightened densities of susceptible individuals in the roost during this period. Smaller colonies of bats, such as those occupying bridge crevices, tend to exhibit greater innate immune response and may have reduced parasite loads, potentially increasing probabilities of survival following exposure to rabies virus. Smaller bridge crevices also appear to have more stable temperatures and relative humidity levels, and a spatial orientation that limits individual contact, contrary to the high contact rates that can occur in the dense clusters of bats that are typical of cave roosts. Predictions about the dynamics of disease transmission and infection in populations of bats require data on individual, colony, and landscape level variation in roosting ecology, immune function, and pathogen exposure. We present evidence that the immune response of gregarious Brazilian free-tailed bats varies with local and landscape differences in roosting ecology and pathogen pressure, and further use these data to generate predictions for response to exposure to rabies virus across highly variable landscapes.

Attacks of Vampire Bats upon Native People and their Animals in Northern Brazil
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The outbreaks of human rabies transmitted by the common vampire bat *Desmodus rotundus* upon indigenous people are not known in Brazil. However, there is an unpublished and unconfirmed report of rabies in two young native Apinajes, transmitted by this bat in the Amazonian region in 1998. On the other hand, the attacks by vampire bats upon Native Brazilians and their animals (mainly dogs and chicken) are a common phenomenon in different places of Brazil. In March 2005, we started a survey of the occurrence of attacks at Brazilian indigenous villages and we verified that they are concentrated in the Amazonian region. The three vampire species have been netted at native villages: *D. rotundus* was feeding mainly on humans, dogs, chickens, and cows while *Diaemus youngi* and *Diphylla ecaudata* were feeding only on chickens. These interactions were recorded in several Amazonian tribes, such as Kayapo, Yanomami, Tucano, Apinaje, Arara, Xipaia, Tikuna, Karipuna, and Waiãpi. More than 600 natives have been bled by the common vampire bats. Between July and November 2005, an aggression outbreak occurred at three Kayapo villages from State of Para, where more than 200 natives were bled by bats. From December 2005 to December 2006, vampire bats were netted at ten indigenous villages of Para; nevertheless their attacks on humans were observed only at Arara, Xipaia, and Kayapo villages. At two Kayapo villages, with many bled people, the population growth of *D. rotundus* seems to be related to cattle-raising by the natives themselves. Many cows rested at the villages and the bats got food from both sources: cows and humans. The anti-rabies immunization of the native people (post-exposure prophylaxis) and of their dogs and cats, and the vampire bat population control were our measures to prevent rabies outbreaks from taking place at these indigenous villages in northern Brazil.

Body Lesions in the Common Vampire Bats from Southeastern Brazil and their Possible Relation to the Intraspecific Rabies Transmission
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The social organization of the common vampire bat *Desmodus rotundus* is very complex, including the establishment of hierarchy and harem. This organization could be established by agonistic interactions which could involve "discourage displays" and fights with bites. These aggressive behaviors are important to rabies transmission. Here we consider that all body lesions in *D. rotundus* were caused by bites between fighters. We checked the body lesions in 11 groups (colonies and bachelor groups) of *D. rotundus* of two municipalities of São Paulo State, Southeastern Brazil. Between October 2002 and April 2003, 268 bats were netted in front of diurnal roosts and all of them were checked for body lesions. The average size of the colonies (females, males, and juveniles) was 41 bats and of the bachelor groups was 26. Intruders of *D. rotundus* were mostly males and were captured while they were entering the roosts. The majority (67.4%) presented some type of lesion on their body. These lesions were found more frequently in males than in females, but the difference was not statistically significant. From 191 males, 91% showed lesions while from 67 females, the percentage was 70%. The main lesions (n = 287) found in *Desmodus* were perforations in wings (61%), in interfemoral membranes (11.5%), mutilated ears (26.8%), and excoriations and scars (0.9%). The wing perforations must have little importance to rabies transmission; however the lesions in ears, face, trunk, arms, and legs must be the main entrance of the rabies virus to the bat's body. Our data show that body lesions are common in *D. rotundus* from Southeastern Brazil and could be an important route to rabies intraspecific transmission (inside and between groups). Male intruders must be important to the transport of the rabies virus from one group to another of the same region and to other regions as well.

Reproductive Biology and the Evolution of Columnar Cacti in Mexico

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Columnar cacti (tribe Pachycereeae) are one of the most conspicuous and important ecological groups of plants over vast areas of arid-semiarid regions of America. The group is distributed from southwestern United States to Mexico, the West Indies, and northern South America—Mexico being the area with the highest diversity and south-central Mexico being where species harbor plesiomorphic features. In this presentation, I synthesize the biogeographical, historical, and the ecological evidence concerning the reproductive biology of this group of plants in order to analyze its radiation. The results indicate that although columnar cacti are absent from the sedimentary fossil record, their early evolution occurred during the Tertiary, linked with the evolution of early tropical forests, and the evolution of nectar-feeding bats, the most important pollinators. Indeed, 72% of columnar cacti have a bat-flower syndrome, but the specialization to bat pollination seems to occur only within the tropics, whereas extratropical cacti are pollinated by a wide spectrum of animals including birds, bats, and bees. This dichotomy found within and outside the tropics among columnar cacti with bat-pollinated flowers is explained as a consequence of the predictability of pollinators throughout the year. We hypothesize that events such as the uplift of the Sierra Madre Occidental, the separation of the Baja California Peninsula, and the large climatic fluctuations that occurred during the Quaternary were the most important scenarios that contributed to the unpredictability of pollinator presence over different geographical areas, leading to different speciation events, reflecting selection by pollinators such as nocturnal moths, hummingbirds, and bees.

Cryptic Diversity in the *Hipposideros caffer* Group Inferred from the Cytochrome *b* Gene

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Roundleaf bats of the genus *Hipposideros* represent a substantial part of the species spectrum of the Paleotropic family Hipposideridae. The Afrotropic *H. caffer* group, traditionally regarded as a complex of populations pertaining to one of two species, belongs to the most abundant savanna bats. In 2002–2007, a considerable number of roundleaf bats of this complex were collected in SE Senegal. Morphometric analysis indicated existence of three size-distinct forms and initiated a survey of phylogenetic relationships within this complex on molecular level. Based on analysis of complete sequences of the mitochondrial gene for cytochrome *b*, a distinct inner structure of the *H. caffer* complex was revealed, with three well differentiated lineages on the species level. Haplotypes of the smaller form of the complex, originally designated *H. caffer* (Sundevall, 1846), split into two groups that can be considered separate species. One of them, the currently recognized subspecies *H. caffer tephrus*, deserves to be reclassified into the separate species *H. tephrus* Cabrera, 1906. In the larger, and according to our material, more abundant form, *H. ruber* (Noack, 1893), a high haplotype diversity led to the formation of two sympatric lineages that might further increase diversity in the *H. caffer* complex. [This survey was supported by grant IAA6093404 from the GAASCR.]

Molecular Phylogeny Amends Systematics of the *Rhinolophus ferrumequinum/clivosus* Complex

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The Greater Horseshoe Bat (*Rhinolophus ferrumequinum*) and Geoffroy's Horseshoe Bat (*Rhinolophus clivosus*) represent relatively large rhinolophids distributed throughout a major part of the Old World. We analyzed extensive material of both species originating mainly from the West Palearctic and from the Afrotropics, using morphological and molecular genetic approaches. Morphometric analysis divided the examined specimens of various geographic origin into groups basically responding to two known species, although large individuals of *R. clivosus* conformed in size to smaller ones of *R. ferrumequinum*. In both species, cline shifts in metric characters were present and the largest representatives of *R. ferrumequinum* met the smallest bats of the *R. clivosus* rank in the southern Levant. Molecular phylogenetic analysis of the *Rhinolophus ferrumequinum/clivosus* complex based on complete sequences of the mitochondrial gene for cytochrome *b* showed five main lineages. Most distinct was the Libyan form of *R. clivosus* from Cyrenaica, which constitutes a new species within the complex, although formerly it was assigned to the nominotypical form. Among remaining lineages, the East Asian subspecies *R. f. nippon* turned out to be the most divergent. Two others were composed of respective forms of *R. clivosus*: the South African form *augur* and the Yemeni form *acrotis*, which included also the smallest form of the complex from Socotra. The third lineage comprised little divergent haplotypes of both species from the West Palearctic. Size-distinct Egyptian forms *clivosus* from Sinai and *brachygnathus* from the Nile valley showed close affinity. In *R. ferrumequinum*, the Middle Eastern haplotypes from Iran, Israel, and Syria slightly diverged from the compact European sublineage, which also contained bats from Crete. Similar low divergence was shown between North African haplotype of *R. ferrumequinum* from Morocco and *R. clivosus* from Libyan Tripolitania. On the DNA level we proved that the high phenotype variation in the *R. ferrumequinum/clivosus* complex does not respond to the genetic variation. This suggests a relatively quick and recent spreading throughout the Afrotropics and Palearctic. Our view on the *R. ferrumequinum/clivosus* complex represents a challenge for taxonomic revision of the *ferrumequinum* group. [We thankfully acknowledge grant support from the GAASCR (IAA6093404) and the GACR (206/05/2334).]

Chemical Signaling during Mating Season of *Cynopterus sphinx* (Short-nosed Fruit Bat)

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Bats use a combination of visual, auditory, tactile, and olfactory cues to assess individual identity, food sources, and roosting sites. In the nocturnal life of bats, olfactory cues play an important role in gathering information as well as communication. 'Chemical signals' coordinate all social activities, including reproduction in a colony of bats. They are important because of their effectiveness in darkness, efficacy over long and short distance, are long lasting, and are efficient informers of genetic compatibility of individuals. Specific odoriferous chemical signals are effective through the exchange of information between individuals in a harem of *Cynopterus sphinx* (the common tent-making short-nosed fruit bat) during mating season. A harem of 12 individuals roosting in the ornamental palm tree near Bat Research Laboratory, Sarah Tucker College (Ele: 436 ft, N 8°21.59', E 77°30.75') has been continuously monitored during the mating season (March–May 2006). The colony members were tagged with Avinet plastic bat bands with reflection stickers. The secretions from skin glands, saliva, and urine were collected periodically from the adult male and female members of the harem and analyzed through Gas Chromatography-Mass Spectrometry (GC-MS). The kin recognition, selection of mate, and the scent marking behavior were video graphed and correlated with the chemical signals. Chemical cues play an important role in the maintenance of social structure and sexual status. These factors are immensely responsible for bringing reproductive success in a race.

Structure and Diversity of Bat Ensembles of Central and Southern Campeche, Mexico

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We evaluated the spatial and temporal fluctuations of bat diversity, their reproductive patterns, their ensembles, trophic groups, and bio-indicator species in central and southern Campeche, Mexico. We sampled bats during 96 nights with a sampling effort of 17,406 ± 10,677.35 m^2mh from September 2000 to November 2006. We recorded 1,911 bats of 29 species, and 7 families of which Phyllostomidae is the richest with 17 species. Nayarit de

Castellot is the most diverse area and with the highest evenness, but Hampolol is significantly different from the other areas by having seven unique species. We found 15 insectivores, 9 frugivores, 2 carnivores, 2 sanguivores, and 1 nectarivore species. The frugivores are the most abundant trophic group with 1,632 individuals for all the areas. The indicators of disturbance were *Artibeus jamaicensis*, *A. lituratus*, *A. phaeotis*, and *Carollia perspicillata*; while sensitive species to disturbance were *Vampyrum spectrum*, *Lampronycteris brachyotis*, *Micronycteris schmidtorum*, and *Lophostoma brasiliense*. Tropical semi-deciduous and sub-humid forests of Calakmul differed in bat diversity from the tropical sub-humid forest of Hampolol and Nayarit de Castellot. Dominant species showed two reproductive peaks: 1) from March to June, and 2) in October. Sites associated with body of waters had the highest diversity, but no specific preference to the habitat was found. In conclusion, two dynamics of bat ensembles are depicted: 1) ensembles associated with sites that have superficial water and some degree of disturbance, and are characterized by a high number of reproductively active individuals and the presence of species adaptable to land cover change; and 2) ensembles associated with sites that have higher arboreal cover without the presence of superficial water, and are characterized by low diversity, low number of reproductively active individuals, and presence of species sensitive to human disturbances. However, trophic diversity is not associated with a particular dynamic.

Bat Road-killing Nearby "El Volcán de los Murciélagos" Cave, Calakmul, Campeche, Mexico

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There are some caves in Mexico near high-traffic roads that probably are impacted by this human activity. Furthermore, bats killed by cars are unknown particularly in the surroundings of El Volcán de los Murciélagos Cave in the Calakmul Municipality, southern Campeche, Mexico. This cave is a dry cenote and it is one of the most important bat roosts in the Mexican tropic that harbors from hundred thousands to millions of bats of seven insectivorous species (*Mormoops megalophylla*, *Pteronotus parnellii*, *P. davyi*, *P. personatus*, *Natalus stramineus*, *Myotis keaysi*, and *Nyctinomops laticaudatus*), and one nectarivore (*Glossophaga soricina*). The Escárcega-Chetumal Highway segment is a two-way road located 700 m south from the cave. Two road transects of 500 m each close to the cave were sampled to evaluate bat road-kill by car impact. After our first visit to this site, a mean of 21 recently hit individuals per night and a lack of information on the impact of this road on the cave bat populations suggested an important source of unnatural mortality. This made the application of a short-term monitoring necessary to evaluate such impact on bat populations. One hundred and twenty-three dead bodies of five bat species, two unidentified birds, and a mouse were recovered in three different sampling sessions. The impact of bat road-kill in this segment is considered high and mitigation action is proposed.

Seasonal and Vertical Diversity of Chiropterochorous Fruit in Relation with Vegetation Complexity in Calakmul, Mexico

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We analyzed the relationship among seasonal and vertical bat-fruit density and biomass with habitat complexity in three plant communities in southern Mexico from August 2002 to August 2003. We characterized the vegetation using Gentry's method, its complexity was calculated using the Holdridge index, and fruit density was estimated using direct and extrapolation methods at < 3 m, 3–6.5 m, and > 6.5 m height. To determine chiropterochorous species we collected feces from bats caught in nets. Floristic diversity varied among plant communities (2.83–3.34), as well as their complexities (1.86–205.98). We found significant differences in fruit diversity among sites, vertical levels, and seasons. We recorded 20 chiropterochorous species of which 10 showed a short fruiting period (< 3 months), 6 species had a long fructification pattern (> 4 four months), 3 were grouped into the bimodal pattern (two fructification peaks in two seasons), and 1 showed an undefined pattern (fruit production was irregular throughout the year). We found two fructification peaks: the first occurred during the dry season in the humid tropical forest and the second (and the highest) was found during the rainy season in the tropical semi-deciduous forest and modified open areas. We recorded greater fruit density in the canopy than in the understory. Chiropterochore plants were categorized based on their fruit density as: high (> 40,000 fruit ha^{-1}, e.g., *Ficus* spp. and *Muntingia calabura*); intermediate (10,000–40,000 fruits ha^{-1}, e.g., *Spondias mombin* and *Vitex gaumeri*); and low production (< 10,000 fruits ha^{-1}, e.g., *Solanum rudepanum* and *Pouteria campechiana*). Our results showed that forested environments are more complex, harbor more chiropterochore species, and had greater variability of fruit sizes than modified environments. However, there was no relationship between habitat complexity and fruit density or biomass.

Seasonal Niches of Migratory Bats: Spatial and Temporal Distribution of the Mexican Free-tailed Bat *Tadarida brasiliensis mexicana*

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Migratory phenomena in bats are a poorly understood process despite numerous studies undertaken on several migratory species. We describe the spatial and temporal characteristics of the migration events of the bat *Tadarida brasiliensis mexicana* using ecological niche modeling (ENM). The GARP algorithm was used with 19 variables corresponding to temperature and precipitation values to generate models of potential geographic distribution with which to evaluate monthly and seasonal movement. Latitudinal movement was confirmed through visualization of monthly records and a bioclimatic profile analysis was performed to obtain seasonal patterns. We observed that during migration, the species does not track the same environmental conditions. Ecological preference varies for its reproduction sites and throughout the species' movement range. For the first case (winter-summer reproduction sites) mean temperature (14.8–24.7°C) and precipitation (173–949 mm) ranges were particular and similar even when geographic separations of up to 1,500 km occur between winter and summer

localities of the same population. In the latter case (the spring-autumn movement range) the previous specificity is lost (mean temperature 7.1–28.4°C and mean precipitation 71–1,113 mm), displaying a wider 'niche amplitude' shared by both seasons. Decision-making strategies for conservation within and across borders are being discussed in light of these results.

Scaling and Structure in a Neotropical Bat Assemblage, an Ecomorphological Approach
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One of the main objectives of ecology is to identify the factors that determine the structure of communities, as well as the role played by deterministic, local, stochastic, and regional processes in their organization. An approach used to investigate local factors, such as competitive exclusion, is the analysis of morphological traits of species, under the assumption of morphology reflecting ecological relationships. The objective of this study was to analyze the structure, at different geographical scales, of a bat assemblage and its ensembles through a combine set of approaches including ecomorphology, macroecology, and null models to elucidate patterns of organization. The area of study comprised the Mexican region called the Isthmus of Tehuantepec. A nested set of quadrants was overlaid to the region and the species whose geographic range intersected the region were considered. We took morphological measures of the wing and skull for each species, and built an ecomorphological space for each type of measure (wing or skull) based on a principal components analysis of the original variables. Then, we measured the volume of the space and the average distance between species within such volume. The scale effect was determined by relating the latter measures to the scale of analysis. To contrast the real assemblages and test for statistical differences, we used random assemblages based on a null model. We found no significant effect of scale for the assemblage and two ensembles; the volume space doesn't increase with scale, contrary to the pattern shown by the random assemblages. This could indicate that local processes might not have a pervasive influence in the morphological structure of the assemblage. Therefore, regional, historical processes appear to be more important for the assembly of this Neotropical assemblage.

Sites for the Development of Large-scale Wind Energy in Mexico and the Potential Impact on Bats
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Mexico is currently promoting the development of alternative sources of energy. Wind energy is non-polluting, inexhaustible, and slows down the exhaustion of fossil fuels—thus contributing to buffer global climate change—and it is considered a mature renewable technology. This energy is currently undergoing the fastest growth in the world in comparison to other renewable energies. For the past several years, several studies have been conducted in Mexico on wind intensity across the territory to explore possibilities and maximize the use of this renewable energy. A potential to produce wind energy for 5,000 MW has been recorded, and the Isthmus of Tehuantepec in Oaxaca has been identified as the area with the greatest potential in Mexico, with 2,000 MW. However, the peninsulas of Baja California and Yucatan could also generate as much as 1,200 MW. There are also clear environmental risks in the wind energy plants: noise, visual impact, and the mortality risks to birds and bats by collision with the wind generators. These variables must be taken into consideration when designing wind energy parks in Mexico. Mexico is the fifth country in the world in terms of species of bats, with a total of 139 species. Two of the three areas with the greatest potential for wind energy generation are potentially rich in bat species: the Isthmus of Tehuantepec with about 71 species and Yucatan with about 37 species, while Baja California is poorer. Most species are frugivores or other species that tend to fly in cluttered areas such as forests or shrub areas, but still an important number of species are aerial insectivores that tend to fly in open areas. Further, many of these are migratory species and some are included in the list of federally protected species. On the basis of previous studies in other countries, the most vulnerable species include lasiurines and several species of molossids. Studies are currently under way to determine the level of vulnerability of these species to wind energy developments and to promote mitigation measures.

Social Structure and Olfactory Signals in Greater Sac-winged Bats
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Bats are well known for their acoustic abilities, but recent findings demonstrate that olfaction may as well be an important sensory modality for bats, especially in the context of social communication. Like other Neotropical emballonurid bats greater sac-winged bats have wing sacs in their front wing membranes that contain an odoriferous liquid. In colonies, males fan the scent of their wing sacs to colony members, preferably females, during a greeting flight. We asked what role the odor plays in the harem-polygynous mating system of *Saccopteryx bilineata*. Analyses of male scent profiles using gas chromatography and mass spectometry revealed that the wing sac liquid contains nine male-specific substances, of which two were new to science. Six of the male-specific substances found in *S. bilineata* occur as well in male scents of the sibling species *S. leptura*. Because both species occasionally share the same roost, we asked whether female *S. bilineata* use male scents as a pre-mating isolation barrier. Preference tests showed that females preferred the wing sac scents of male *S. bilineata* over those of *S. leptura*. We also detected population and colony differences in the male scent profiles, suggesting that the wing sac may act as a composite trait. Recent genetic analysis revealed that colony males are related to each other, caused by male natal philopatry owing to limited roost availability. Possibly wing sacs have evolved in *S. bilineata* and in general in emballonurid bats in response to the necessity to assess the relatedness of potential mating partners in patrilineal societies.

A Mammalian Nectar Specialist Fuels Its Metabolically Expensive Nocturnal Life Directly and almost Exclusively with Exogenous Carbohydrates
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Nectar bats mostly consume a diet low in both fat and proteins, but rich in simple carbohydrates. Although metabolizing exogenous carbohydrates directly to fuel, their high mass-specific metabolic rate would save nectar bats the energetic costs of lipogenesis and gluconeogenesis; therefore, we expected them to switch to exogenous carbohydrates rapidly when available and use them predominantly instead of fat or glycogen. We investigated the rate of fractional incorporation of dietary sugars into the pool of metabolized substrates in *Glossophaga soricina* by measuring the change in ^{13}C enrichment of exhaled CO_2 ($\sigma^{13}C_{breath}$)

when animals were fed glucose, fructose, or sucrose that was isotopically distinct from their normal diet. Secondly, we performed a diet-switch experiment to estimate the turnover rate of fat tissue. When fed with either mono- or disaccharides, the $\sigma^{13}C_{breath}$ converged quickly on the isotope signature of the ingested sugars, indicating an almost exclusive use of dietary carbohydrates. The time for a 50% carbon isotope exchange in exhaled CO_2 equalled ca. 10 to 15 minutes in all three types of sugars. Nectar bats fuelled on average 80–95% of their metabolism with exogenous carbohydrates. Each day bats depleted 50% of their fat stores. Although nectar bats consumed most of their body fat each day, this was still barely enough to sustain their diurnal metabolism. The fractional incorporation rates of dietary sugars into the pool of metabolized substrates in *G. soricina* are the fastest rates ever found in a mammal.

Phenotypic Convergence in Two Species of South African Horseshoe Bats: Evidence for Local Adaptation

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Local adaptation was investigated in the horseshoe bat, *Rhinolophus clivosus*, by comparing its phenotype and ecology to that of *R. capensis*, a sympatric endemic (i.e., locally adapted) species at De Hoop Nature Reserve, South Africa. We predicted that if *R. clivosus* has become locally adapted its phenotype should converge on that of *R. capensis*, provided they occupied the same niche. The dietary niche of *R. clivosus* and *R. capensis* overlapped in the proportions of moths and beetles consumed (all $Z > 0.47$, df = 4; all $P > 0.57$) and in the size ranges of prey taken (*R. capensis* 1.2–15.2 mm; *R. clivosus* 2.1–18.7 mm), suggesting that the two species occupy a similar ecological niche. The squared Mahalanobis distance in morphometric space between *R. capensis* and *R. clivosus* ($D^2 = 60.5$) was smaller than that between *R. capensis* and *R. clivosus* from an allopatric site ($D^2 = 83.0$), suggesting that the sympatric *R. clivosus* has converged on *R. capensis* as predicted. The convergence was mainly evident in body size with allometric responses in wingspan and wing area. The high frequency, high duty cycle calls of *R. capensis* (n = 19, 84.0 ± 1.2 kHz) and *R. clivosus* (n = 18, 92.0 ± 0.92 kHz) were typical for the family Rhinolophidae and adapted for foraging in cluttered habitats. However, *R. clivosus* called at a higher frequency than expected for its body size, but this deviation from allometry was not associated with prey size or habitat use. Competition and gene flow may have prevented further convergence between *R. capensis* and *R. clivosus* at De Hoop. It is also possible that the convergence observed is a result of phenotypic plasticity rather than local adaptation. Further insight into the dynamics of environmental and genetic factors underpinning phenotype may help tease apart these variables in future.

Methods to Promote Bat Conservation Outreach and Education Through Science- and Research-Based Activities

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Bat researchers worldwide agree that raising public awareness about the importance of bats to natural and agricultural systems is vital to the conservation of these poorly understood animals. One often under-appreciated component of a well-rounded research project is educational outreach. Community education programs that complement a research project can be especially important in areas where bat conservation and values of bats to healthy ecosystems are not well known. Bridging gaps between scientists and communities can ensure that study animals receive on-going protection and may help future research in the area by encouraging locals to identify roosts, protect colonies, and pass legislation to increase community awareness for conservation. Educational specialists have postulated that environmental education programs may be more crucial to long-term conservation success than biologically focused scientific work. Fortunately, focused scientific research offers an opportunity to develop science-based environmental education as a component of multidisciplinary research and conservation efforts. Today there exist many bat conservation organizations and governmental natural resource agencies that often include bat management and conservation goals in their programs. In the past 25 years there has been a marked increase in the numbers of educational resources about bats and opportunities for partnerships that can assist researchers with outreach activities. This paper recognizes a merging relationship between pure scientific research, conservation, and environmental education programs. In it, we offer bat scientists some practical suggestions about how they can integrate education and outreach goals into their research programs and projects. Through the use of case studies we will provide real world examples of how public education and outreach can be accomplished through conservation science and research-based activities.

Landmark Use in Spatial Orientation by *Myotis myotis*

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All bats use echolocation for spatial orientation. When flying from the roosts to the hunting grounds, bats often follow specific routes along linear landscape structures. We hypothesize that a route consists of a sequence of places defined by landmarks. This study investigates the use of landmarks for spatial orientation in *Myotis myotis*. Six bats were trained in a flight room to land onto one of 64 regularly arranged platforms. Flight paths and echolocation behavior were recorded. Reflectors positioned at the edges of the platform array as well as the array itself served as possible landmarks. By shifting either potential landmarks or the starting point, we tested the relevance of these potential landmarks in a place recognition task. The precision of place recognition increased with decreasing distance between the learned place and the landmarks. Moreover, both array and reflectors were used as landmarks, and in some cases idiothetic cues were also relevant for a landing decision. The longer bats had been trained to land on a certain place, the more often idiothetic information was used for place recognition. Thus, landmark orientation combined with idiothetic cues is employed for place recognition in *Myotis myotis*.

Bat Diversity and Activity: A Comparison Among Texas Army National Guard Sites

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Five Texas Army National Guard training sites (Camp Bowie, Camp Swift, Fort Wolters, Camp Maxey, and Camp Mabry) were surveyed for bats using mist nets and ANABAT units during spring, summer, and fall seasons from October 2005–September 2006. Previous floral and faunal studies conducted at each of the sites indicate that unique habitat differences exist among sites. These sites differ in overall size, amount of improved grounds, amount of water present, and biotic communities. Additionally, the sites differ in the amount of National Guard training activities, which may affect bat foraging activity. To better understand the relationship between the observed bat assemblages and environmental variables, a canonical correspondence analysis (CCA) was performed. The most frequently captured bats were *Lasiurus borealis* and *Nycticeius humeralis* followed by *Myotis velifer, Perimyotis subflavus,* and *Tadarida brasiliensis*. Two records for Lamar County (Camp Maxey) include *Lasiurus seminolus* and *Lasiurus cinereus*. The highest frequency of bat activity and diversity of bat species was at Camp Maxey, a site that also includes the greatest number of invertebrate species, the least improved grounds, and the most available water. Conversely, Camp Swift exhibited the lowest overall bat activity, a site that also displays the fewest insect orders.

Hunting High and Low: Vertical Stratification of Bats in a Neotropical Lowland Forest
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Neotropical bat communities are exceptionally diverse. This is mainly due to the diverse feeding ecology of Phyllostomids, the most speciose family of bats in the Neotropics. Phyllostomids feed on a variety of food items such as fruits, nectar, pollen, insects, vertebrates, and blood. Resources are divided among species not only in terms of food type, but also foraging habits, including differential use of space in three dimensions. Though temperatures in the tropics do not vary strongly, rainfall is seasonal and influences community dynamics of bats strongly by controlling food and roost availability for many species. I studied the vertical stratification, community structure, and seasonality of the Neotropical bat community in a lowland semi-deciduous forest in Panama. I used high net walls and ground level mist nets to sample the bats throughout the forest strata during the wet and dry seasons. Many bat species were found throughout the vertical forest levels, whereas some species were preferentially captured within a small vertical range. The forest understory showed the least bat activity, whereas the canopy was utilized most. Overall, community diversity and bat abundance was higher when the sub-canopy and canopy forest levels were included in sampling, thus changing the abundance rank within the community of many species. A significant seasonal shift of foraging stratum was not found for any of the studied species, but several bats show seasonality in their occurrence or abundance.

Broadening Our Focus in the Conservation of Bats in the United States
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Conservation efforts have historically focused on bats that are concentrated in space and time. As elsewhere, bat conservation in the United States targets species that form large, conspicuous aggregations during some portion of their annual life cycle. These species dominate lists of threatened species. Furthermore, conservation and research efforts tend to focus on time periods during which bats are easy to observe. We have a wealth of information on large maternity colonies and conspicuous hibernacula for a limited number of species, but what about mating, overwintering, and migration strategies in the majority of species that do not form large, obvious aggregations? Relative to species with less gregarious habits, it is easier to identify threats and population changes in concentrated bats and conservation actions are more likely to produce tangible results. Although this focus on concentrated bats is fully warranted, we argue that the future of bat conservation will involve widening our focus to identify more nefarious threats that influence more species, and possibly have greater cumulative impacts than focal threats. We explore how emerging threats such as global warming, energy production, and wildlife disease might influence the survival of all bats and not just those that form dense aggregations. Identification of emerging threats will require gathering more information on the basic natural history of bats as well as targeted studies into the influence of anthropogenic stressors on the fitness of bats.

Spatial Changes in Bat Assemblages of the Salinas Valley in Monterey County, California
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Based on historical capture data that is spatially defined, sixteen bat species are potentially present in the Salinas Valley of central coastal California during the summer months. Museum specimens with geographic coordinates provide a way to investigate the fine-scale context of the collection site at a given time. The objective of this research is to compare the distribution of bat species during agricultural and urban development of this coastal California region during the past 50 years based on landscape features and defined by aerial photography. Change detection using historical and recent photographs differentiates between natural plant communities from anthropogenic changes in vegetation and structure. Loss of bat species diversity is correlated with habitat degradation. Diversity of bat species is inversely correlated with patch size of intact habitat, and FRAGSTATS metrics are used to interpret and analyze the landscape mosaic. The distribution of present day species is determined by recent records and by surveying for bats along a transect that starts from the west coast at the Santa Lucia Mountains, crosses the Salinas Valley, and continues through the Gabilan Range at the easternmost end. Surveying techniques include the use of passive ultrasonic detectors and mist nets. Observations show that bats use linear features in the landscape more frequently than non-linear areas. The small scale of recent urban development over the past 50 years in a region with bat species sensitive to land use conversion provides a unique opportunity to investigate the effects of agricultural and urban development on the occurrence and distribution of bats in Monterey County.

Bat Activity and the Abundance of Nocturnal Insects in Conventional and Organic Farmland in the United Kingdom
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Agricultural intensification is viewed as a major factor contributing to the recent decline of bat populations in Britain. We investigated the impact of intensification by comparing bat activity at conventional farms with that at organic farms, which prohibit the use of agrochemicals. We compared bat activity and insect abundance at 24 matched pairs of organic and conventional farms. Bat activity was quantified by broadband acoustic surveys, with species identification performed by artificial neural networks. Insect abundance was sampled by Heath light traps, impact taps, and sweep netting. Total bat activity and foraging activity was higher on organic than on conventional farms, and the activity of several bat species was higher on the organic farms. Insect abundance, species richness, and moth species diversity were significantly higher on organic than on conventional farms. Our results support findings from other studies that recognize biodiversity benefits from organic farming, and support the hypothesis that agricultural intensification may have played a role in causing recent declines of insect and bat populations. Further studies investigating the roles of specific habitat features affecting bat activity in agricultural landscapes suggest that changes in hedgerow features may partly determine differences in bat activity between organic and conventional systems.

Bat Community Structure in Traditional and Intensive Coffee Agroforests in the Sierra Madre of Chiapas, Mexico

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The agricultural matrix surrounding remaining forested areas serves critical functions as dispersal corridors and alternate habitat for wildlife. However, the value of agroecosystems for maintaining biodiversity usually varies with agricultural intensification. To evaluate the value of different agroforestry systems in maintaining bat communities, we studied the abundance and diversity of bats in four habitat types ordered along a gradient of management intensity: forest fragments; traditional polyculture (high shade); commercial polyculture (medium shade); and commercial monoculture (low shade) coffee. Between November 2006 and January 2007, we surveyed bats in 12 sites in the Sierra Madre Mountains of southwestern Chiapas, Mexico. This landscape is dominated by coffee agroforestry. Bats were captured between 1800 and 0500 hours on 24 moonless nights (two nights per site), using ground-level mist nets, triple-high mist-net systems, and two 3.25 m^2 harp traps. During 1,590 mist-net hours (MNH), we captured a total of 1,759 bats of 41 species representing 27 genera in 5 families. Abundance-based estimators suggest a total of 53 species in the landscape as a whole. Although species richness declines with increasing management (from 31 species in forest fragments to 24 species in low-shade plantations), differences in richness and diversity were slight. However, bat abundance (captures per MNH) was significantly lower in the monoculture coffee plantation (forest: 1.15/MNH, high-shade: 1.16/MNH; medium-shade: 1.43/MNH; low-shade: 0.64/MNH). Members of four common Neotropical frugivorous genera (*Artibeus*, *Dermanura*, *Glossophaga*, and *Sturnira*) accounted for 78% of captures. The proportion of frugivores captured increased with management intensity, while captures of nectarivores and insectivores decreased as intensification increased. Our results suggest that less-intensively managed coffee agroforests serve as valuable feeding and commuting areas for Neotropical bats, including phyllostomine species more vulnerable to habitat modification. Additional results from sampling in May and June 2007 will also be presented.

Behind the Cameras: Kruger Kid's National TV on Bats

John Winkelmann and Frank Bonaccorso

We participated in the filming of two environmental education television programs for broadcast on national television in South Africa. Our present paper has the goals of providing a photographic documentation of the process of producing television programs that report science in action and reviewing the benefits to science from participation by engaged scientists in mass media public education. The programs focused on research of our bat-plant interaction research in Kruger National Park. The programs bridged wildlife management issues, the role of bats in ecosystems, and the importance of basic research on bats. One program was an adult evening news show, 50/50, and the other was a science and conservation show focused on young teenagers. Thus two different audiences were targeted with a total audience potentially exceeding 10 million viewers. Although time is lost from limited field research schedules, the effort to reach a very large segment of the general public, both adults and youths, represent opportunities for conservation scientists to report directly on issues of educational content that in the long term will benefit our conservation goals and promote science in the public sector.

Determining the Distribution and Seasonal Patterns of Nectar-feeding Bats by Monitoring Hummingbird Feeders in Tucson, Arizona

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Two species of nectar-feeding, cave-obligate bats, the lesser long-nosed (*Leptonycteris curasoae*) and the Mexican long-tongued (*Choeronycteris mexicana*), forage at hummingbird feeders in Tucson, Arizona, USA. The Tucson metropolitan area, with about one million inhabitants, lies between maternity roost-sites of lesser long-nosed bats and their late-summer roost-sites. In 2005, about 40 volunteers monitored their hummingbird feeders and recorded dates and times of bat presence, levels of activity, and behavior. We identified species using a video camera with supplemental infrared lights, and mapped the distribution of each species. Lesser long-nosed bats used feeders in high-density neighborhoods as well as lower-density residential areas, and traveled farther into town than was expected. This species was first noticed at feeders in late August. Activity was heaviest beginning about the third week of September and ended in October. A linear relationship between the time lesser long-nosed bats first arrived at a feeder and the distance from the feeder to one of the nearby late-summer roosts suggested the source of these bats. The study served as an educational opportunity, and promoted awareness, knowledge, and appreciation for bats among the volunteer monitors and their families and friends. Monitoring hummingbird feeders is an inexpensive and low-tech method to determine the distribution and seasonal patterns of nectar-feeding species in Arizona. Monitoring feeders may provide information on other nectar-feeding species as an alternative or complementary technique to mist-netting or acoustic surveys. Educating people about bats that come to hummingbird feeders near their homes may also promote knowledge and tolerance for bats, particularly in areas where vampire bats have become a problem.

Effects of Habitat and Climatic Variables on Bat Foraging Activity and Prey Availability in Southern Pine Forests

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Forests of the southeastern U.S. are changing rapidly in species composition and extent of forest cover due to increasing conversion to pine (*Pinus* spp.) plantations, intensifying management practices, and expanding urbanization and sprawl. Questions related to the impacts of these changes on wildlife species are of great conservation interest and management relevance. Bats, with their large home ranges and complex habitat requirements, may be especially vulnerable to increasing human modification of landscapes. However, the impacts of such modifications on bat species are poorly understood. We sought to evaluate bat community structure and foraging activity in regenerating managed pine systems in the central Virginia Piedmont. We conducted this research in the Appomattox-Buckingham State Forest in June–

August 2006 and 2007. We sampled sites representing a continuum from 0–1 year-old released loblolly pine plantations to 8–10 year-old stands. In each site we established a sampling array consisting of a central bat detector and four associated insect sampling locations. We assessed bat activity (1930 to 0630 hours) with Anabat II bat detector systems, calculated mean bat passes per hour, and identified calls to genus or species. We collected and analyzed insect samples and assessed vegetation attributes using standard procedures. In the 2006 season, mean bat passes per hour were 7.06 ± 7.96 (mean ± SD) in the youngest pine stands, 4.22 ± 3.85 in intermediate stands, and 3.13 ± 2.24 in the oldest stands. We also report insect biomass and percent of catch for each of five taxonomic categories. To understand factors affecting bat activity, we used an Information Theoretic approach to evaluate support for a suite of *a priori* models that included measures of habitat attributes, climate conditions, and prey availability. In this on-going work, our goals are to understand bat activity patterns and habitat use in actively managed forest landscapes and to provide data to inform conservation and management decisions.

Post-natal Development of the Japanese Tube-nosed Bat, *Murina leucogaster*

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The Japanese tube-nosed bat, *Murina leucogaster*, is known to gather in caves only in certain seasons. Adult bats are found in some caves from January to the end of May, but they suddenly disappear in June. Thereafter, during nursery season for the bats, their roosts in are rarely found in the wild. Therefore, little information exists regarding the post-natal development of this species. Since 2002, year-round banding of this species has been carried out in the area around the Akiyoshi-dai, which is the largest limestone plateau in Japan, and pregnant female bats have been trapped. A female bat that was caught in May 2004 gave birth to one male infant, and another bat caught in March 2006 gave birth to twins (one male and one female). These females and their infants were released after the infants became volant and independent. In the winter of 2007, one of the twins from 2006 was located near the point of initial release. In this presentation, we report on the maternal care and post-natal development of these bats. Although the results of observations made under captive conditions are not the same as those made under natural conditions, we believe that the detailed data that we have collected with respect to bat development allow us to predict certain aspects of the *Murina leucogaster* lifestyle.

Observations of Cavity-roosting Behavior in Costa Rican *Lophostoma brasiliense* (Chiroptera: Phyllostomidae)

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Of the five currently recognized species of round-eared bats of the genus *Lophostoma* (Chiroptera: Phyllostomidae), three (*L. brasiliense*, *L. carrikeri*, and *L. silvicolum*) are remarkable in that they are known to occupy roost cavities within the arboreal nests of termites (Isoptera: Termitidae: *Nasutitermes*). Termite activity raises the temperature of the roost, likely rendering it more suitable for reproductive females and pups, and it also may offer protection from parasites and predators. This roosting behavior has been described in great detail in *L. silvicolum*, which is reported to have a harem mating system. Further, males of this species have been shown to excavate and maintain the roost, with up to 19 individuals occupying the roost at a given time. In contrast, only two accounts of *L. brasiliense* roosting in termite nests are known, both from South America, and neither offers information about bat group size and composition or the physical characteristics of the roost. Herein, we report the first observation from Central America of *L. brasiliense* occupying a termite nest. At the Bijagual Ecological Reserve in Costa Rica, five bats—one male, one female, and three of undetermined sex—were observed in a cylindrical cavity within a termite nest, which we tentatively suggest is consistent with the harem mating system observed in other members of the genus. The roost cavity appeared to be unaffected by termite activity while it was occupied, although it eventually was filled in by the termites after the bats were absent from the roost for an extended period of time.

Bat Fauna and Taxonomic Status of China

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In China, few people research one of the most important orders of Mammalia, Chiroptera. But our Bat Research Group has been studying bats—taxonomy, ecology, zoogeography, physiology, genetics, neuroscience, virology, biomagnetism, and parasitology—for ten years. We present an overview of the bat fauna and their taxonomic status in China, which includes results on the discovery of a new species of the genus *Barbastella*, found in Beijing, phylogenetics (e.g., taxonomic status of *Rhinolophus pusillus*, phylogenetic diagnosis of *Myotis pequinius*), and new records for the country (e.g., *Rhinolophus marshalli*, *Rhinolophus stheno*, *Myotis hasseltii*). Meanwhile, we added more provincial records of bat species, and now we know the wider distribution on some species (e.g., *Rhinolophus pusillus*, *Myotis adversus*), which extend to more areas in North China. [Funded by a Zijiang Scholarship of East China Normal University and a Darwin Initiative grant.]

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ZOOGEOGRAPHY

Genoways, H. H., P. A. Larsen, S. C. Pedersen, and J. J. Huebschman. 2007. Bats of Saba, Netherlands Antilles: a zoogeographic perspective. Acta Chiropterologica, 9: 97–114. [Univ. Nebraska State Mus., W436 Nebraska Hall, Lincoln, NE 68588; hgenoways1@unl.edu]

BOOK REVIEW

Bats in Forests. M. J. Lacki, J. P. Hayes, and A. Kurta, editors. Johns Hopkins University Press, Baltimore, Maryland. 329 pages. 2007. ISBN 0-8018-8499-3. ($85.00 U.S.)

This eleven-chapter volume is the proceedings of a symposium on bats and forests, which was held in Little Rock, Arkansas, in 2004. Its explicit purpose was to summarize research and technological advances that had occurred since the First Bats and Forest Symposium, which was conducted in Victoria, British Columbia, in 1995. This second collection is a must for anyone interested in the ecology, conservation, or management of forest bats in the United States and Canada. An introductory chapter by M. Brigham provides a superb synthesis of "what we know and what we need to learn," emphasizing (as do many of the authors) the need for rigorously designed, empirical research, and the importance of expanding research to include broader temporal and spatial scales.

Three chapters are devoted exclusively to roosting ecology and behavior. R. M. R. Barclay and A. Kurta undertake the rather daunting task of summarizing information on roosting behavior of species that roost in tree cavities and under bark. Although one wishes that their presentation could have been more concise, it is extremely thorough in identifying key issues and the limitations of research conducted to date. Their contribution is sufficiently valuable that one can overlook minor errors—for example, the claim that all species in Canada and the United States weigh < 50 g (there are several that are larger), listing *Corynorhinus townsendii* as a tree-roosting bat based on a paper that is actually about *C. rafinesquii*, and not citing two papers that are relevant for *C. townsendii*. T. C. Carter and J. M. Menzel address issues of foliage-roosting bats in a chapter that focuses primarily on species from eastern North America, sometimes overlooking available information on western species, particularly the western red bat. P. C. Ormsbee et al. synthesize information concerning night-roosting and emphasize the importance of including this often-overlooked aspect of behavior when developing forest-management practices.

Paul Cryan and J. P. Veilleux provide an excellent summary on migration and what little is known regarding seasonal roosting needs for migratory species, stressing the need for more research, particularly investigation of migratory corridors and roosting requirements in fall, winter, and spring. M. J. Lacki et al. address foraging ecology and provide a particularly helpful synthesis of methods for measuring and evaluating habitat use by bats—for example, the advantages of kernel methods over convex-polygon techniques for estimating area used. Their paper concentrates on the structural features of foraging habitat. Although they briefly discuss the diet of bats, the authors make only passing reference to the potential impact of forest-management practices on the insect assemblage, and thus the prey base for bats. T. Weller reviews the challenges associated with assessing the status of bat populations with available survey methodology and suggests that application of modern analytic techniques, particularly use of presence/not-detected data, can help with this task. He also argues for development of standardized protocols and centralized databases to allow pooling of information over larger spatial scales.

Four chapters focus primarily on management issues, particularly as they relate to silviculture. Guldin et al. provide an excellent, educational review of silvicultural practices. They also offer concrete suggestions regarding how silviculturists and bat biologists can work together to accommodate their respective goals. J. Hayes and S. Loeb provide a thorough and concise overview of the interface between forest management and the ecological requirements of bats. The authors importantly emphasize that “understanding quantitative relationships of abundance and viability of bat populations with habitat characteristics at multiple spatial scales is central to understanding the responses of bats to forest management.” As a potential stimulus for future research, they offer conceptual models illustrating hypothesized relationships between abundance of bats and key ecological parameters influenced by forest management. Duchamp et al., in their chapter on ecological considerations for landscape-level management, argue persuasively for biologists to expand their investigative scope to spatial scales that encompass the areas actually used by the species of bat being studied. While offering appropriate caveats regarding limitations of models, they present a clear and useful example of how habitat suitability indices can help elucidate the ecological requirements of bats at a landscape scale. Finally, Wigley et al. present a candid evaluation of the challenges regarding management of bats on forest-industry lands, where the emphasis is on even-age stands and, from a bat’s perspective, short rotation times. They provide geographically diverse examples of how issues concerning bats are addressed by particular companies.

There are a few inconsistencies in this volume, the most striking of which is lack of agreement regarding which species are forest bats. The Preface identifies 27 tree-roosting species, whereas Chapter One states there are 25 species that use forests for roosting or foraging. In fact, if foraging habitat is included, the list should be considerably longer. For example, molossids form a significant component of the forest-dwelling bat assemblage in the Southwest, but they are barely mentioned in the book and never in relation to management issues. This makes the photograph of a mass exodus of *Tadarida* on the dust jacket a puzzling choice. While the volume is comprehensive in the topics selected, there is a geographic bias among the authors, with only two authors from Canada, four from the Pacific Northwest, and none from the Southwest. Consequently, some important forest habitats (e.g., pinyon-juniper or mixed montane conifer) and their particular management issues are largely overlooked. This book, nevertheless, fills important gaps in the scope of the earlier symposium, which had focused on the western United States and Canada. This new volume comprehensively reviews the issues and research tools currently available for addressing bat-forest issues anywhere in North America.

Elizabeth D. Pierson, Center for Biological Conservation, University of California, Berkeley, California.

ANNOUNCEMENT

Announcement from *Bat Research News*

Original research/speculative review articles, short to moderate length, on a bat-related topic would be most welcomed. Please submit manuscripts as MSWord documents to Allen Kurta, Editor for Feature Articles (akurta@emich.edu). If you have questions, contact either Al (akurta@emich.edu) or Margaret Griffiths (griffm@lycoming.edu). Thank you for considering submitting some of your work to *BRN*.

FUTURE MEETINGS and EVENTS

26–28 March 2008
The 13th Australasian Bat Society Conference will be held at Charles Sturt University, Thurgoona, NSW, Australia. For general information about the meeting, please contact Craig Grabham (**craig.grabham@ghd.com.au**); for information about abstract submission, please contact Lindy Lumsden (**Lindy.Lumsden@dse.vic.gov.au**).

18–22 August 2008
XIth European Bat Research Symposium (EBRS) will be held in Cluj-Napoca, Romania. For information about the meeting, please see the EBRS Web site: **http://www.ebrs2008.org/** or contact the organizers at: **ebrs@aplr.ro**

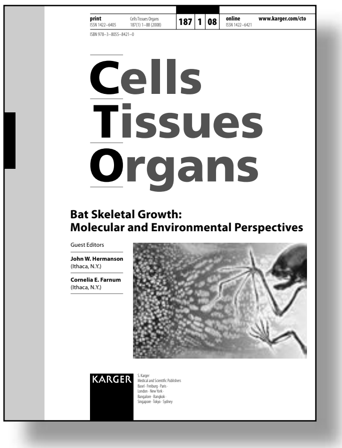
22–25 October 2008
The 38th Annual North American Symposium on Bat Research (NASBR) will be held in Scranton, Pennsylvania. For information, please see the NASBR Web site: **http://www.nasbr.org/**

4–7 November 2009
The 39th Annual NASBR will be held in Portland, Oregon. Please see the NASBR Web site for information.

August 2011
XIIth European Bat Research Symposium will be held in Lithuania.

Journal Publication

New insights on bone growth and limb development



Bat Skeletal Growth: Molecular and Environmental Perspectives

Editors

John W. Hermanson
Cornellia E. Farnum

Anatomy; Zoology; Molecular Biology, Embryology, Evolutionary Biology, Biomechanics, Limb Development

The ability to perform true flight with a wing has set bats aside as unique and important vertebrates. How the hand of a primitive mammal might have evolved into a hand-wing remains an elusive yet challenging question facing biologists. This special issue was designed to bring together ideas about the growth and development of bats, specifically looking to integrate ideas on how the bat wing emerges as a unique structure from the embryonic hand, and where some of the most rapid growth occurs within the growth plates of the long bones. Contributions range from analysis of the molecular determinants of bone growth in bats, to growth and function of juvenile bats, and concluding with a study of the biomechanical demands placed upon the bones of the adult wing.
The publication will be of special interest to scientists working on limb development and bone growth, including those who use a molecular or a gross approach to their studies.

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Front Cover Photograph

The SEM photograph on the front cover is that of a mite, tentatively identified as *Steatonyssus periblepharus* Kolenati, 1858 (Mesostigmata: Macronyssidae). It was collected from *Pipistrellus pipistrellus* in Oxfordshire, UK by Joel Tigner (Batworks, South Dakota) and identified by Dr. Anne Baker (Research Acarologist, Natural History Museum, London). The mite was photographed using a scanning electron microscope by David Dixon (Department of Chemical and Biological Engineering) and Ed Duke (EMES), both from South Dakota School of Mines and Technology, Rapid City, South Dakota. Many thanks to Joel and his colleagues for sharing their find with us!