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Front Cover Illustration

Dick Wilkins of ***Bat Rescue***, Poway, CA provided this wonderful photo of a *Nyctinomops femorosaccus*. This female bat was recovered from a local lake clinging to the side of a aluminum rental boat. After several weeks of rest and recovery it was flown on a zipline, echolocation sounds were recorded and the bat was released back at the lake.

Farewell from the Editor

Dear Subscribers to Bat Research News,

In the last issue of Bat Research News I announced that this issue would be my last as Editor and Publisher. What began as a temporary commitment in 1977 grew into a five year assignment, followed by several more "five year commitments" and now 27 years later it is time to retire, (it may even be past time). During all those years I have had the able assistance of many dedicated individuals. Dr. Brock Fenton, then of Carleton University in Ottawa, Canada was my Associate Editor from 1977 to 1982. He was succeeded by Dr. Kunwar Bhatnagar of The University Louisville, in Louisville, Kentucky who served as Associate Editor until 1987. Dr. Thomas Griffiths at Illinois Wesleyan University in Bloomington, Illinois then became my able associate and assumed the role of Editor for Recent Literature until he was succeeded in 2003 by Dr. Margaret Griffiths, also of Illinois Wesleyan University, as Editor for Recent Literature. Margaret will become Editor and Publisher of Bat Research News on June 1, 2004 in time for the publication of Volume 45: No. 2 (Summer 2004). Dr. Allen Kurta of Eastern Michigan University in Ypsilanti, Michigan will continue in his role as Editor for Feature Articles and Patricia Morton of Texas Parks and Wildlife in Austin, Texas will continue as Editor for Education and Conservation. Dr. Margaret Griffiths is also the Director of the Annual North American Symposium on Bat Research and as director of the symposium and editor of the journal she will most assuredly play a major role in chiropteran affairs in the future. You will undoubtedly see a marked improvement in the quality of the journal as she assumes responsibility for all aspects of its production.

I owe a special debt of gratitude to all of the individuals mentioned above. They have served with enthusiasm, good grace and great patience as they assisted in getting Bat Research News to you. I also wish to thank Robert Stebbings and his staff at Stebbings Consultancy in Peterborough, England, Peter Lina in Leiden, Holland, Uwe Schmidt in Bonn, Germany and Michael Augee in Kingsford, NSW, Australia for their invaluable assistance in distributing Bat Research News to our foreign subscribers.

During these years, 27 volumes have appeared, totaling just over 80 separate issues with 2,500 printed pages. This amounted to approximately 35,000 copies to the U.S.A. and 40 foreign countries. The entire opus weighed over six tons. I certainly could not have done this without the eager assistance of literally dozens of my students who have helped with typing, sorting pages, stuffing envelopes, licking labels, sending out invoices, and helping to lug cartons of copies to the post office every couple of months for nearly three decades. And thank you, Ruth, for your patience and support. I could not have, nor would have, done it without you, and now you will have all my attention, full time!

Thank you all for allowing me this opportunity to be involved with you and your interesting and fascinating work with bats and their biology. Good luck to all of you, and especially to you Marge!

All the best,

G. Roy Horst, Managing Editor and Publisher , **retired**.

The Automated Ultrasound Recorder: A Broadband System for Remotely Recording Bat Activity in the Field

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Patterns of habitat-use by microchiropteran bats can be difficult to monitor. Visual observation is of little use with animals that are small-bodied, fast-moving, and active largely at night. Bats can be caught in mist nets or harp traps to confirm which species are present at a site, but some species are caught more easily than others. Capture is also disruptive and, therefore, likely to influence the patterns of habitat-use being studied. An alternative method is to record ultrasonic vocalizations and use them as a measure of activity. This method has become widely adopted in bat surveys.

Using Hand-held Detectors

One method of estimating bat activity in relation to habitat type is for fieldworkers with hand-held detectors to travel along transects. While this approach has been successful (e.g., Vaughan et al., 1997a; Glendell and Vaughan, 2002; Russo and Jones, 2003), it is labor intensive, because each fieldworker can record data at only one location at any one time. There is also a tendency for data collection to focus on particular times of year and times of day, when activity levels are likely to be high. It is common practice, for example, to sample only during the first few hours after dusk (e.g. Vaughan et al., 1996; Warren et al., 2000; Glendell and Vaughan, 2002; Russo and Jones, 2003). Results may be misleading if patterns of habitat-use vary through the night. Surveys also tend to use accessible routes, such as rides or pathways, which may result in an underestimate of bat activity in less accessible areas.

Another potential problem with surveys using hand-held detectors is that workers may unintentionally create disturbance that influences the bats' behavior. Walking transects often results in noise and may necessitate use of lights, and both of these actions could reduce bat activity. For example, Swift (2000) found that captive *Myotis nattereri* reacted to lights by retreating immediately to their roost box and staying there until the light was switched off. Similarly, Shirley et al. (2001) found that local disturbance caused *M. daubentonii* to emerge from their roost up to 47 min later than usual. Furthermore, effects of disturbance may not be equal in all habitats, because movement through more cluttered habitats, such as woodlands, likely creates more noise than movement across a glade.

Remote-detection Devices

An alternative to hand-held detector surveys is to use devices that remotely record ultrasound. This allows all-night recording, is less labor intensive, and can be used to monitor activity in habitats that would be difficult or dangerous to move through at night. Very simple and effective automated devices can be built around heterodyne bat detectors (O'Donnell and Sedgeley, 1994). These are suitable when an overall measure of bat activity is all that is required (e.g., Park et al., 1999; Zbinden, 1995) or in habitats where the few species present can be readily distinguished with a heterodyne detector (O'Donnell and Sedgeley, 1994). Such systems are of limited value, however, with more complex communities, especially if there is a need to separate species or species groups.

One alternative is a system based on a frequency-division detector, such as the Anabat (Titley Electronics, PO Box 19, Ballina, NSW 2478, Australia). The Anabat uses associated zero-crossing software to extract frequency-versus-time data and can be automated to operate remotely. It has been widely used in studies of bats in Australia and the Americas (e.g., Hayes, 1997; Humes et al., 1999; Ochoa et al., 2000; O'Farrell et al., 2000). Frequency division retains some characteristics of the call but loses others. It is most suitable for studying communities of bats in which calls of each species are well known and readily distinguishable from those of other species present. However, in situations where this is not the case, a system based on a broadband recording system that preserves key acoustic parameters is preferable.

The Automated Ultrasound Recorder (AUR)

We developed the Automated Ultrasound Recorder (AUR) to meet our own need for a broadband remote recording system. The AUR incorporates a time-expansion detector, which has the advantage of retaining most information from ultrasonic calls (Parsons et al., 2000). This maximizes the chances of correctly differentiating between species whose calls are similar (e.g., for British bats, several species of *Myotis*—Vaughan et al., 1997b). Preserving key acoustic parameters also means that novel calls that cannot be identified immediately, such as unusual social calls or calls of previously unrecorded species, can be analyzed comprehensively at a later date.

The AUR is a compact, portable, and automated system, consisting of a Pettersson D140 detector, a cassette tape recorder (Sony WM-D6C Professional Walkman), a control unit (built by P. Reed, University of Sussex), and a 12-v battery. The system is housed in a plastic toolbox (40 by 20 by 18 cm) to protect the equipment from the elements, and the microphone of the detector is mounted behind a small opening (ca. 2 by 2 cm) cut into the side of the box. The AUR can be hidden effectively by covering it with vegetation, as long as the microphone is not obstructed.

The D140 is a time-expansion detector that records 0.87 seconds of ultrasound (one registration), stores it, and is then able to play it back, slowed down by a factor of ten, making it audible. The control unit is designed to switch on the tape recorder once the D140 has been triggered by sound. An 18-kHz high-pass filter in the control unit ensures that the recorder is switched on only when the D140 detects ultrasound. Once the recorder is activated, the registration stored in the D140 is recorded onto one of the two channels of the tape recorder. The control unit then puts a signal on the other channel immediately after the ultrasound recording, which encodes time and day. There is also a programmable clock in the control unit that allows the unit to switch itself on and off at set times (e.g., civil sunset and sunrise). A resistor in each AUR allows sensitivity to be adjusted, so that multiple AURs can be triggered by a sound of the same intensity.

The tapes that we used were TDK IEC 1/TYPE 1 (Normal Bias 120 µs EQ) that recorded for 120 or 90 min; these allowed up to ca. 344 and 257 registrations, respectively, to be recorded in one continuous sampling period. Although the D140 is no longer manufactured, the unit has been modified to work equally well with newer models (e.g., D240). Recordings of calls can be analyzed using the BatSound acoustic analysis software produced by Pettersson Elektronik.

Testing of AURs

The purpose of the AUR system is to provide a systematic method for monitoring bat activity remotely in a variety of situations. The use of multiple AURs allows simultaneous monitoring, but the detection range and the recordings made by each AUR should be similar, so that results are comparable between them. Tests to quantify the maximum receiving area of three AURs and to evaluate how similar they were to each other were carried out using a synthesized, ultrasonic, frequency-modulated sweep (frequency of maximum energy = 50 kHz; maximum intensity at 50 kHz = 80–90 dB peak sound pressure level at 1 m) emitted by the Sussex AutoBat (a programmable, synthesized ultrasound player designed by D. Hill, F. Greenaway, and P. Reed at the University of Sussex—Hill and Greenaway, in press). These tests established that the mean maximum detection range for three AURs was comparable and that there was little difference in call parameters measured for a repeated call, either for individual AURs or between them.

The maximum receiving area of the AUR will depend on its location, climatic conditions, and intensity of the calls of nearby bats. Mean maximum detection range likely is more for bats giving louder echolocation calls and/or social calls. Future testing will include determining effects of proximate vegetation and other factors (e.g., effects of recording over water) on maximum receiving area of AURs and quality of calls recorded.

Summary

We have successfully used this system in a variety of recording situations, including habitats that are very difficult to access at night (e.g., a wood with a dense understory of holly), in comparisons of activity at ground level and just below the canopy, and in recording previously unreported social calls at a roost of Bechstein's bat (*Myotis bechsteinii*) (Fitzsimons, 2004). Because the AUR is automated, quiet, and unobtrusive, it is unlikely to disturb the bat's natural behavior. One researcher with several AURs can monitor many different habitat-types simultaneously, even those that are dangerous or impractical to monitor in person at night. Using a back-pack frame and both hands, up to five AURs can be carried comfortably over 500 m by the average person. Future versions could incorporate lighter batteries, which would decrease weight considerably. Replacing the cassette recorder with a hard drive would allow longer, continuous sampling times, and thus, AURs could to be left in situ over many nights. Using the AUR system requires someone to place and collect them at either end of a sampling period, but this is achievable by one person, who does not need any special bat expertise, and can be completed during the day. We believe the AUR system can make an important contribution to the study of bats in multi-species communities by providing a non-invasive method for systematically recording the key acoustic parameters of bat calls.

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Predation on a Rafinesque's Big-eared Bat in South Carolina

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On 17 August 2002, we entered an abandoned building at Hampton Plantation State Historic Park, Georgetown Co., South Carolina, to observe a colony of Rafinesque's big-eared bats (*Corynorhinus rafinesquii*). The park lies alongside the Santee River delta, within the Lower Coastal Plain of South Carolina. A maternal colony of 25–200 Rafinesque's big-eared bats occupies year-round the second-floor attic of an abandoned kitchen building, and the colony has been there for at least 40 years (R. Mitchell, Hampton Plantation State Historic Park, pers. comm.). The attic is triangular in shape, with timber rafters angling inwards and meeting along a center ridge. A brick chimney extends from the first floor, through the center of the attic floor, to the roof of the building. Maximum height of the room is ca. 2.5–3.0 m.

When we entered the attic, two yellow rat snakes (*Elaphe obsoleta quadrivittata*) were resting on the floor near the entrance to the attic. We estimated colony size at 58 bats, and most of these were roosting on the slanted wall panels or hanging from rafters near the ceiling; they were grouped in tight clusters toward the back of the room, away from the entrance and the snakes. Several bats were flying sporadically, possibly due to disturbance caused by our presence. As we counted the bats, one snake moved toward the crumbling chimney, began to climb, and subsequently was lost from sight. The other snake, however, remained on the attic floor, and we noticed a bat in its mouth. The bat was alive and attempting to escape, with its right wing extending from the snake's mouth. After a few minutes, the snake finished its meal and retreated out of sight.

Although we did not observe the snake capture the bat, we speculate that the snake climbed one of the rafters and caught a bat as it landed among the rafters or that the bat was taken prior to our entrance as it rested in the rafters. Rat snakes are excellent climbers and usually forage in trees for bird eggs and small mammals. Since rat snakes are nonvenomous and constrict their prey, it is possible that the snake was in the process of killing the bat by constriction when we initially saw it. It seems likely that the snake intentionally hunted the bat and not opportunistically scavenged it.

There are no records of yellow rat snakes preying on bats, but rat snakes (*Elaphae guttata*) have been found in roosts of Rafinesque's big-eared bats in Louisiana and are thought to feed on them (Jones, 1977). In North Carolina, a rat snake was observed to approach a solitary big-eared bat, although the snake retreated after being startled by humans (Clark, 1990). In addition, several rat snakes were observed hanging from the rafters in an abandoned building in North Carolina near a nursery group of Rafinesque's big-eared bats, but predation was never documented (Clark, 1990). Rat snakes, including yellow rat snakes, may be important predators of Rafinesque's big-eared bats in the Coastal Plain of the southeastern United States.

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New Record of Two Species of Myotis from Distrito Federal, México

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Mexico City covers nearly the entire "Distrito Federal," and only the southern part has a small area that still supports wildlife. Of the few areas still having natural conditions, the greatest part is in the delegación (county) of Milpa Alta. Milpa Alta is in the Ajusco-Chichinautzin region; although it is not a protected area, the Comisión Nacional para el Conocimiento y uso de la Biodiversidad (National Commission for Understanding and Study of Biodiversity) has listed it as a priority region for conservation in Mexico. Knowledge of wildlife in the area is limited (Ceballos and Galindo, 1984; Sanchez et al., 1989; Villa-Ramirez, 1953), and for this reason, we began studying the mammals of Delegación Milpa Alta in 1999.

Although our survey covered all of Delegación Milpa Alta, one site near La Quinta, D.F., 11 km S and 2 km E of Santa Ana Tlacotenco (19° 04'N, 98° 58'W), at 2850 m, yielded a very high number of bats. This location is in the southern mountains near the border with the state of Morelos. Of the 11 species collected in the study area, eight (*Myotis californicus, M. thysanodes, M. velifer, M. volans, Eptesicus fuscus, Lasiurus blossevillii, L. cinereus*, and *Corynorhinus mexicanus*) were found in this one locality. Of those eight species, *M. thysanodes* and *M. volans* were recorded for the first time in the region and the Distrito Federal. Skins and skulls of each were deposited in the mammal collection of the Laboratorio de Cordados Terrestres at the Escuela Nacional de Ciencias Biologicas of the Instituto Politecnico Nacional.

Five, adult, male Myotis thysanodes aztecus were collected. The closest previous locality was 5 km N of Tlayacapan, Morelos (Alvarez-Castañeda, 1996). The fringed myotis were collected in a mist net that was set over a spring pool of a creek in an area that was surrounded by fir forest (Abies religiosa). Average (range) length of testis in May and July was 3.4 (2.0–5.0) mm; total length, 88.6 (85.0–91.0); length of tail, 34.8 (33.0–36.0); length of hindfoot, 9.4 (9.0–10.0); height of ear, 18.0 (17.0–19.0); length of forearm, 42.9 (41.5–45.0), and body mass, 7.0 g (5.9–7.8). The greatest length of the skull was 16.6 (16.1–17.0); length of maxillary tooth row, 6.2 (6.0–6.4); length of mandibular tooth row, 6.8 (6.7–6.9); zygomatic breadth, 10.3 (10.1–10.4); breadth of braincase, 7.9 (7.7–8.2); interorbital breadth, 4.2 (4.1–4.4); and depth of brain case, 6.0 (5.8–6.4).

Thirty-seven *Myotis volans amotus* were collected at the same location. The nearest published records for the species were from 1.5 km NE of San Juan Tlacotenco, Morelos, Mexico

(Guerrero-Enriquez et al., 1996). However, after examining those earlier specimens, we concluded that they actually were *Myotis californicus*, having all the characteristics mentioned by Miller and Allen (1928). Consequently, the record from San Juan Tlacotenco was invalid, and the nearest known occurrence of *M. volans* was from the western side of Popocatepetl Volcano, in the State of México (Ceballos and Galindo, 1984).

Twenty-five females were collected in May; two carried embryos (15.0 and 18.0 mm), and five were in lactation. Of these, one had a hairless offspring with closed eyes that was attached to a nipple. In July, 18 females were collected, but none had signs of reproductive activity. Twelve males also were collected in July, and average length of the testis was 4.0 (3.0–5.0) mm. Average total length for 25 females and 12 males, respectively, was 89.8 (84.0–95.0) and 88.5 (85.0–93.0); length of tail, 40.0 (36.0–46.0) and 39.8 (36.0–45.0); length of hindfoot, 8.1 (8.0–9.0) and 7.8 (6.0–9.0); height of ear, 13.3 (12.0–14.0) and 12.6 (9.0–13.0); length of forearm, 39.4 (38.5–40.6) and 38.7 (37.5–39.9). Greatest length of the skull was 14.3 (13.9–14.5) and 14.0 (13.6–14.3); length of maxillary tooth row, 5.3 (5.0–5.5) and 5.2 (5.1–5.3); length of mandibular tooth row, 5.6 (5.5–5.8) and 5.6 (5.4–5.8); zygomatic breadth, 8.7 (8.3–9.0) and 8.5 (8.1–8.9); breadth of braincase, 7.2 (6.8–7.4) and 7.0 (6.8–7.6); interorbital breadth, 3.9 (3.7–4.1) and 3.9 (3.6–4.1); and depth of braincase, 5.4 (5.1–5.7) and 5.3 (5.1–5.6). These measurements were similar to those reported by Ramirez-Pulido et al. (1980).

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A Novel Maternity Roost of Big Brown Bats (*Eptesicus fuscus*)

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In the eastern United States, maternity colonies of the big brown bat (*Eptesicus fuscus*) generally are located in buildings, such as barns and houses (Kurta and Baker, 1990), but I recently discovered an unusual roosting site for these bats. From June to August 2003, a maternal colony of big brown bats was studied at the Kresge Environmental Education Center of Eastern Michigan University, on Fish Lake, in Lapeer Co., Michigan. The bats roosted primarily in two bat boxes that were located on the west side of a dormitory, and as part of my study, some bats were tracked via radio transmitter (Model BD2B; Holohil Systems, Ltd., Carp, Ontario, Canada) to locate other roosts.

One of these alternate roosts was behind a plastic guard on the south side of a wooden utility pole (Fig. 1) that was situated about 175 m west of the dormitory. The pole was 9 m high and 27.5 cm in diameter. It was located at the end of an electrical distribution line, where three overhead wires passed down the pole and then went underground to a nearby transformer. As the insulated wires passed vertically down the pole, they were protected from disturbance by a metal pipe close to the ground and C-shaped plastic guard above the pipe. The guard was ca. 3 m long and ca. 11 cm wide, and the pipe was a 2.4-m long and of similar diameter. The pole was adjacent to a gravel drive, and there was a small shed just to the southeast. An ash (*Fraxinus*) and an oak (*Quercus*) were within 5.5 m of the pole and shaded the pole from the east/northeast.

The pole was first used as a roost by a lactating big brown bat with a radio transmitter on 15 July; she also was tracked there on 17 July. Later, a post-lactating female was tracked there on both 18 and 19 August. This unusual roost was used quite frequently, as evidenced by an accumulating guano pile beneath the steel pipe. In addition, bats emerged from this roost on 10 of 11 other nights that the pole was observed at dusk, and even on days when the pole was not observed at sunset, bats often could be heard vocalizing during the late afternoon. Most bats emerged at the top of the plastic guard, but a few exited at the junction of the plastic guard and steel pipe. Emergence counts ranged from 4 to 25 individuals (mean 14.2 ± 6.1 *SD*), and most bats immediately flew south/southwest into a nearby section of woods. Members of this colony also were radiotracked to two large (65-cm diameter) oaks, where the bats roosted under exfoliating bark, and to a barn. The trees were about 240 m east of the bat boxes, whereas the barn was 1,350 m east of the dormitory.

Utility poles occasionally are used as roosts by other species, as well. Harvey (2002), for example, mentions a male Indiana bat (*Myotis sodalis*) roosting underneath a metal bracket on a wooden pole in Arkansas, and Silva-Taboada (1979) reports velvety free-tailed bats (*Molossus molossus*) roosting inside the crevice of a wooden electrical pole. Because utility poles are almost ubiquitous, they may offer potential roosting sites for other species of bats, especially in areas where natural sites are lacking.

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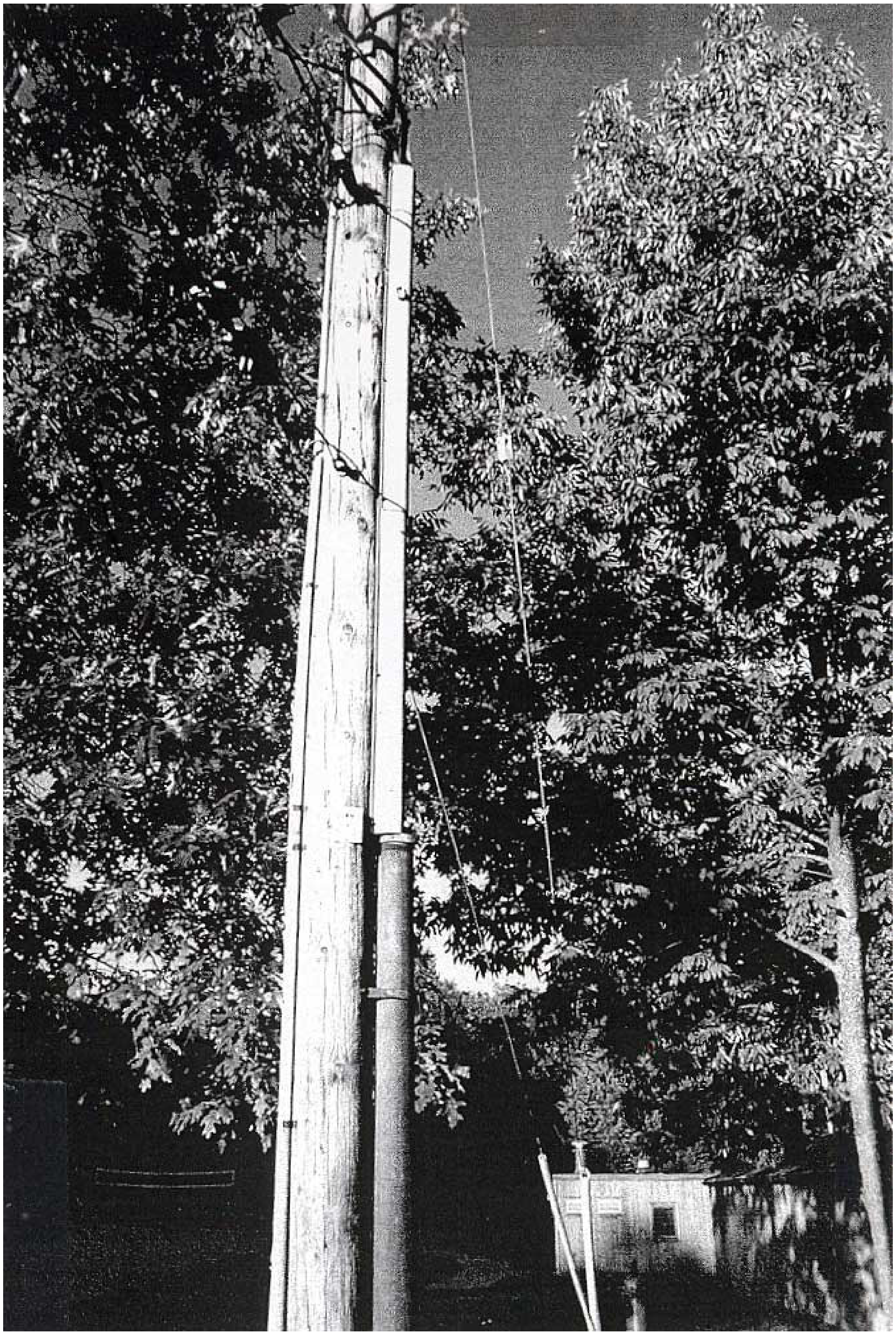

Figure 1. Maternity roost of big brown bats on a utility pole. Bats roosted between the wooden pole and a C-shaped plastic guard that covered electrical wires running down the right side of the pole.

Body Piercing as a Method of Marking Captive Bats

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Introduction

Reasons for marking individual, bats are many. Whenever a captive individual can be identified from others in a group, captive management techniques improve and options for research increase. There are a number of ways to mark captive bats for both short-term and long-term projects. Paint sticks (e.g., All-Weather® Paintstik®), felt-tipped permanent markers, typewriter correction fluid, and reflective and plastic tapes have been used on bats for short-term studies. However, these products may have toxic properties. Necklaces have been used, with varying success in the field (Barclay and Bell, 1988; Fleming, 1988; Gannon, 1993; Greenhall and Paradiso, 1968; Handley et al., 1991; Heideman and Heaney, 1989; Spencer and Fleming, 1989), but they are unsuitable to mark captive bats. Skin irritation can occur if animals become obese or when food accumulates under the collar (LeBlanc, personal communication). The traditional marking method for long-term research, both in the field and in captivity, has been the wing band. Most bands, however, cause some degree of injury to bats (Baker et al., 2001; Barclay and Bell, 1988; Davis, 1960; Dwyer, 1965; Hassell, 1963; Herreid et al., 1960; Hitchcock, 1957; Perry and Beckett, 1966). Not until the PIT tag (Passive Integrated Transponder tag) has there been a safe and permanent marking device for captive bats (Barnard, 1989), but the drawback to this system is that an animal must be "in hand" for identification. In this paper, we describe body piercing, a permanent marking system that allows individual bats to be identified at a distance.

History of Body Piercing

Of all body-art forms, including body modifications and tattooing, piercing is the most ancient (The Pierced Dragon, 2004). Body piercing is referenced in the Bible. In Exodus 21:5-6, Hebrew servants (ca. 1440 B.C.) pierced their ear lobes to show allegiance to their masters. In Genesis 24:22, Abraham ordered one of his servants to find a wife for his son, Isaac. The servant found Rebekah, and he gave her a Shanf (i.e., earring or nose-ring) as a wedding gift.

The reasons for body piercing are as varied as the cultures practicing the art. For example, the Mayans and Aztecs believed they could reach a higher state of enlightenment and become closer to the gods through tongue piercings. Egyptian pharaohs marked the rite of passage into adulthood through navel piercings, and Roman soldiers demonstrated their manhood, strength, and virility by nipple piercings. In the West, nose piercing first appeared among the "hippies" who traveled to India in the late 1960s (Painful Pleasures, 2004). Later, it was adopted by the Punk movement in the late 1970s as a symbol of rebellion against conservative values.

Procedure for Installing Identification Hardware

The procedure for installing the identification hardware in bats is similar to implanting PIT tags: the similarities are as follows:

a needle is required to insert the device; the device is inserted under the skin; insertion points on the body are the same; when inserted properly, the device is permanent

The following sterile equipment should be ready on a well-lighted clean surface

- sterile latex gloves; cotton balls or Q-tips; towel
- appropriately sized hollow piercing needle;
- appropriately sized barbell with matching size post;
- surgical scrub solution; surgical antibiotic lubricant

Restraint of animal:

At least two people are required for this procedure, one to restrain the animal, and the other to install the device (barbell). Occasionally, a third person may be required to assist during the procedure (see *Procedure* below). The barbell should be installed between the bat's shoulder blades, with the barbell oriented parallel to the length of the body. The bat should be placed on a clean towel, ventral side down, while being gently restrained. One method of restraint is to secure the animal's forearms with the middle finger and thumb while the index finger rests on the bat's back. The pressure applied to the bat should be gentle, but firm, and should not constrict the animal's body by squeezing.

Procedure:

The barbell insertion site should be swabbed with a surgical prep solution (e.g., Techni-Care® Surgical Scrub), using a cotton ball or Q-tip. Then, separate the [two] barbell components and set them aside (Fig. 1). With a Q-tip, apply a thin coating of a petroleum-jelly-based topical antibiotic (e.g., Fougera® Surgilube®) on the first few millimeters of the needle. The ointment serves as a lubricant and antibiotic.

Depending on how much the bat struggles, the person holding the animal may also be able to pinch up a flap of skin with both hands using the thumbs and index fingers (Fig. 2). The skin should be lifted simultaneously in two places to create a long fold that runs ***perpendicular*** to the direction of the barbell. Position the needle at a 90° angle, bevel side up (Fig. 3). With one swift and accurate motion, pierce through the fold of skin (Fig. 4).

Place the hollow-shaft-side of the barbell into the end of the hollow piercing needle. While continuing to pinch up the fold of skin, pull the needle, containing the hollow side of the barbell, through the skin fold. The needle will pull away from the barbell post when the barbell ball meets the skin (Fig. 5). This will prevent the barbell from following through with the needle. Insert the steel-wire half of the barbell into the hollow-shaft side, which should be protruding from the other side of the skin fold (Fig. 5). **Do not release the skin fold until the two barbell components have been snapped together securely.** After the barbell components have been snapped together, the skin fold should be released, and the insertion site swabbed with additional topical antibiotic. Only the two barbell balls should be visible as they emerge from the bat's skin (Fig. 6).

Discussion

The piercing technique should be carried out with as little pain as possible. Therefore, the needle should be run through the pinched skin ***swiftly***. The slower the needle is passed through the skin, the greater the pain to the animal. Nevertheless, no matter how expertly the needle is passed through the skin, piercing can still be startling, so the person restraining the bat should be prepared for a flinch.

Probably, the most important point to remember when piercing is the depth and distance in which the needle is placed in the skin fold. If the needle is placed too shallow beneath the surface, it will eventually migrate out of the body. If it is placed too deeply, the skin will be pinched between barbell balls. Therefore, the pierce should be placed below the top of the fold, approximately ½ the length of the barbell post. In this way, when the pinched skin is released, only the assembled barbell balls will emerge from the relaxed skin.

As with most identification devices, barbells should not be placed in growing animals. When hardware is installed in bats that have not reached adult size, the identification device may migrate out of the body as the animal grows. Furthermore, this procedure is not recommended for free-ranging bats. Not until long-term, captive studies may show that this method can be used safely in the field, should free-ranging bats be pierced.

For those contemplating using barbells as an identification method, it is strongly recommended that only APP-certified piercers (i.e., The Association of Professional Piercers) perform this procedure. If a procedure fails, and the jewelry must be removed, do not repeat a piercing on that individual until all traces of scar tissue have disappeared. This is easily determined by palpating the pierced area.

Barbells may be obtained with metal or plastic balls. We have found that the metal balls lose their luster and color over time. Although, at this writing, we have not used barbells with plastic balls, we will be testing them in the future. Barbells come with round, curved, and straight posts. To date, we have installed only the straight posts. Some piercers believe that the curved post places less tension on the dermal tissue than the straight ones. This is another area for future testing. Round posts (rings) should **never** be installed because they do not fit snuggly to the body and can catch on cage protrusions.

Barbell identification has been used in the following species: pallid bat (*Antrozous pallidus*) as shown in this paper; big brown bat (*Eptesicus fuscus*); Mexican free-tailed bat (*Tadarida brasiliensis*); Jamaican fruit bat (*Artibeus jamaicensis*), and white-winged vampire bat (*Diaemus youngi*). The barbells do not appear to cause irritation beyond that of the normal healing time, nor do they appear to interfere with normal behavior, physiology, and social activities. The authors would appreciate feedback from other bat workers who may use this identification method.

Products Mentioned in Text

All-Weather® B Paintstik®, LA-CO®/Markal® Company, 1201 Pratt Blvd., Elk Grove Village, IL 60007-5746.

Techni-Care® Surgical Scrub, Care-Tech® Laboratories, Inc., 3224 S. Kingshighway Blvd., St. Louis, MO 63139.

Fougera® Surgilube®, Fougera® Pharmaceutical Company, 60 Baylis Road, Melville, NY 11747.

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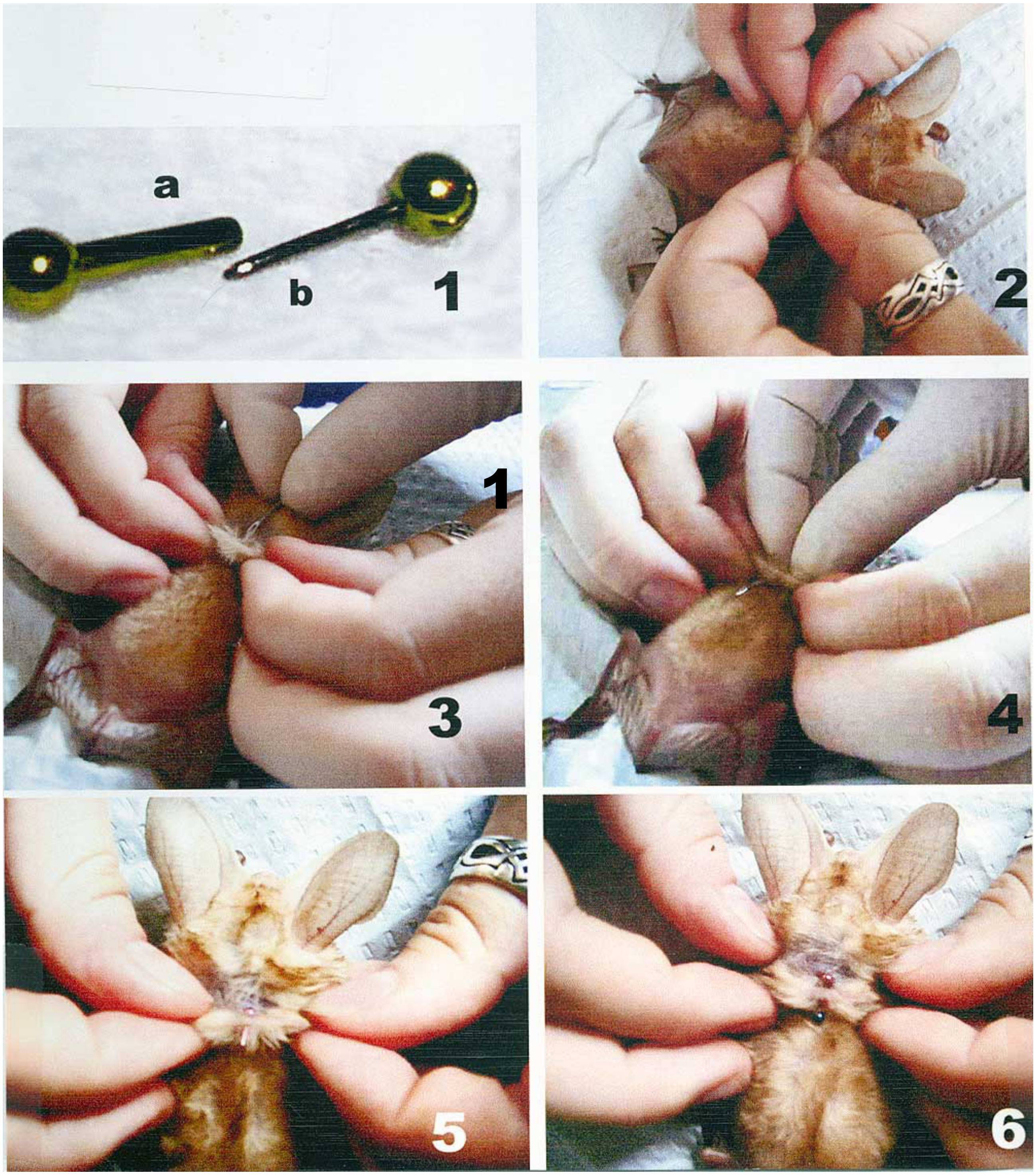
Body Piercing a Pallid Bat (*Antrozous pallidus*)



1) Barbells: (a) hollow side; (b) steel wire side. 2) Prior to inserting the hollow needle, the skin over the shoulder blades must be pinched up. 3) While continuing to pinch up the skin, insert the needle, bevel side up. 4) Swiftly, push the needle through the skin. 5) Insert the hollow side of the barbell into the hollow needle and guide the barbell into place. 6) While continuing to pinch up the skin, insert the steel wire side of the barbell into the hollow side. **Do not let go of the skin until the two sides of the barbell are firmly connected.**

Automated Log-ratio Analysis of Compositional Data: Software Suited to Analysis of Habitat Preference from Radiotracking Data

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Radiotelemetry increasingly is used to investigate habitat use by foraging bats. The technique enables data to be obtained on proportionate habitat use by individual bats over several nights of tracking, and this can be compared with the proportions of habitats available. Standard multivariate analysis designed for unconstrained multivariate data is entirely inappropriate for the statistical analysis of such compositional data (Aitchison et al., 2002). This is because the data are constrained by the fact that the proportions describing habitat use or availability sum to one over all habitat types, an issue known as the constant-sum or unit-sum problem. Compositional data can, however, be assessed by log-ratio analysis (Aitchison, 1986), which also is known as compositional analysis (Aebischer et al., 1993). This technique can be used to assess habitat preference with sample size being the number of tagged animals and the radiolocations providing a subsample of each individual's habitat use.

Compositional analysis is described and demonstrated by Aebischer et al. (1993) using two data sets, including methods of treating missing values representing zero use or availability of habitats for some individuals. The method first determines whether overall use differs from random and, if so, ranks habitats according to relative use and locates significant between-rank differences. Randomization tests are used to determine probability values to overcome problems when assumptions for parametric statistics do not hold.

The manipulation of data and calculations required when carrying out a compositional analysis are laborious and present many opportunities to introduce errors. To assist with such analyses, I have written an add-in program for use with Microsoft Excel that implements fully the method for compositional analysis as described by Aebischer et al. (1993) and presents the final results automatically. The user is required only to provide the observed data as tables of percentage use and availability for the set of animals sampled. Default values are offered for parameters that may be set by the user. Testing for effects is not included in the program but can be achieved by entering log-ratio differences output as intermediate data into a standard MANOVA. My program is called "Compos Analysis" v5.0. Further information can be found on the internet by visiting http://www.smithecology.com/software.htm, which also explains how you can obtain a copy.

Acknowledgments

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Authors are requested to send reprints of their papers to the Editor for Recent Literature (Margaret Griffiths, Dept. of Biology, Illinois Wesleyan Univ., Bloomington, IL 61702-2900, U.S.A.) for inclusion in this section. If reprints are scarce, please send a complete citation (including complete name of journal and author mailing address) to **mgriff@illinoisalumni.org** by e-mail. Receipt of reprints is preferred as it will facilitate complete and correct citation. Our 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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Donald R. Griffin (1915-2003)

Donald Griffin, 1974

Donald R. Griffin died on November 7, 2003. Those of us who study bats, and who try to act variously as their boosters, champions and protectors, have lost a good friend and colleague. Bats have lost one of the people responsible for the change in their reputation from being feared and loathed to being seen as remarkable animals, gifted with the ability to see in the dark by virtue of prior biological development of one of mankind's significant technological achievements—sonar. The North American Bat Research Symposium will miss him as one of the pioneers of modern bat research, along with William Wimsatt and Karl Koopman.

In 1938, as a Harvard University student who was engaged in banding bats to study their seasonal migrations, Griffin was aware of the puzzle—first examined by Lazzaro Spallanzani in the late 18th Century—about how bats oriented in the dark and of Hartridge's untested hypothesis that the basis was acoustic, with sounds that were inaudible to humans. Griffin had the opportunity to bring some bats to an early ultrasonic detector—the precursor of the array of modern "bat detectors" we have for monitoring the ultrasonic sounds of flying bats. It quickly became clear that active bats emitted streams of intense sounds covering a wide range of ultrasonic frequencies. In this work, Griffin described the frequency-modulated (FM) structure of the sounds, which we now know are emitted by the majority of bat species. To determine the significance of these FM sounds by testing Hartridge's theory, Griffin teamed with Robert Galambos, a student in the fledgling field of auditory physiology, which itself had originated just a decade earlier in E. G. Wever's discovery of the electrical potentials that emanated from the cochlea when it transduces sounds. In 1939-41, Griffin and Galambos carried out a series of experiments demonstrating that bats oriented by sonar, a mode of perception that Griffin called *echolocation*. These experiments are classic, not only to those of us who are interested in bats, but to the field of experimental biology because they established the paradigm of neuroethology whereby the sensory worlds of animals are explored. First, bats were shown to be sources of copious ultrasonic emissions. Second, the ability of bats to orient by hearing instead of by vision was confirmed by carrying out obstacle-avoidance tests under various conditions of impairment of senses. Third, the correlation between the pattern of acoustic emissions and the act of orientation was established by recording the sounds of bats with the ultrasonic detector as they flew past the obstacles. Finally, the physiological basis of ultrasonic reception was demonstrated by recording the minute electrical signals of the bat's cochlea while its ear was stimulated with ultrasonic sounds. The critical early discoveries of Galambos and Griffin had a profound effect on the reputation of bats. Henceforth, these animals would be recognized as possessing a genuine, unmysterious technical capability to be admired and studied.

Griffin did his doctoral dissertation on bird migration supervised by the influential physiological psychologist, Karl Lashley, at Harvard and then was on the faculty of Cornell University (1946-1953), Harvard University (1953-1965; Chairman 1962-65), and the Rockefeller University (1965-1989). In the years following the discovery of echolocation, Griffin and his colleagues carried out a series of naturalistic experiments (deliberate manipulations of stimuli in settings where flying bats performed tasks only slightly abstracted from nature) to determine the sensitivity of obstacle detection (with Alan D. Grinnell), to measure bats' resistance to noise jamming (with J.J.G. McCue and Alan Grinnell), to characterize the structure of echolocation sounds in different species of bats, especially in the neotropics (with Alvin Novick), to demonstrate the ability to capture airborne prey and discriminate among airborne targets by echolocation (with Fred Webster, C. R. Michael, and J. H. Friend), to establish that fishing bats used echolocation to detect water-surface ripples caused by prey (with Roderick Suthers), to study the constant-frequency (CF) echolocation of horseshoe bats (with J. D. Pye), to examine the relation between wing-beats and vocalizations (with H.-U Schnitzler), to observe and record horseshoe bats in the field (with J. A. Simmons), to isolate the spectrum of echoes as a cue for discrimination of target shape (with Jack Bradbury), and to do work on cetaceans (with Peter Tyack). The study of neural mechanisms of echolocation was inaugurated by a graduate student, Alan Grinnell, and a postdoctoral researcher, Nobuo Suga, in Griffin's laboratory at Harvard. This work developed into one of the most cohesive stories to emerge in contemporary neuroscience, with a powerful comparative component in the distinction between FM and CF echolocation. Not only did Griffin's "echolocation" colleagues go on to do important scientific work on echolocation or in other areas, but a stream of additional young scientists passed through Griffin's laboratory and then went on to important developments of their own (for example, Michael Menaker, circadian rhythms; James Gould, orientation and communication by bees; Ann Grabiel, systems/behavioral neuroscience; Donald Kennedy, invertebrate neurobiology; Hubert Markl, Darcy Kelley, neuroethology).

At the time of the discovery of echolocation, there were none of the books containing wonderful photographs of bats in all their variety, no calendars with bats for each month, no websites about bats, no elementary school teaching materials about bats, no Bat Conservation International—in short, no sign that bats were regarded as anything particularly worthwhile in the popular imagination. The only general book that was readily available was Glover Allen's *Bats*, which had been published in 1939. Miller's classic taxonomic survey of bats had been done all the way back in 1907. With his wonderfully lucid 1958 book, *Listening in the Dark*, Griffin changed this situation. He began by described the lives of bats and explaining why it was so difficult to determine how they oriented themselves, a difficulty he illustrated by tracing the intriguing work of Spallanzani and Jurine during the late 18th Century. Griffin recounted how he and Galambos worked to solve Spallanzani's "bat problem" and then described in detail the subsequent long series of studies on obstacle-avoidance and detection of flying insects by bats that established the overriding importance of echolocation to the biological success of bats as a group. In 1961, *Listening in the Dark* won the Elliot Medal from the National Academy of Sciences. At about this time, the emergence of new methods in all aspects of biological research combined with a surge in graduate education in science to enlarge the community of people studying bats. This community coalesced into the North American Bat Research Symposium at the first meeting in Tucson, in 1970. An increased public awareness about bats, including a flood of research, publications, and education on their behavior, ecology, and physiology, followed thereafter, but it was the news that bats used sonar to find their way in the dark that initiated the radical change in the way people regarded bats. The Symposium's Gerrit S. Miller, Jr. Award was given to Donald Griffin in 1979 in recognition of his role in the study of echolocation and its impact on understanding about bats.

The discovery of echolocation was made near the beginning of World War II, and the succession of experiments that revealed the sophisticated nature of bat sonar coincided with the rapid wartime and postwar advances in the design of man-made radar and sonar systems. The obvious technological implications of finding that bats, and, later cetaceans, possessed sonar systems capable of high-performance in real time gave real meaning to biologically-inspired engineering. The discovery itself was greeted by astonishment and no small amount of disbelief, but the elegant behavioral experiments done by Griffin, Galambos, and their subsequent colleagues were persuasive, not only in showing that bats indeed use sonar but in recruiting many of us to join the effort to understand what bats perceive by echolocation and how their auditory systems process echoes.

Griffin retired from the Rockefeller University in 1989 to a postretirement career that was as energetically pursued as his earlier career. While at the Rockefeller University, he had begun to write and study about the awareness of animals, hitherto a difficult subject for scientists to grapple with. To this end, he made video and acoustic observations of honeybees using their "dance language," recorded the activity of beavers with tiny video cameras while using microphones to study the noises beavers made in their lodges, and engaged in a large scientific discourse about animal consciousness with enthusiasm. Griffin spent his final years in Lexington, MA working at Harvard University's Concord Field Station, and on Cape Cod, where he was intrigued about a question he had first encountered as a student. In his banding studies of migration in bats, he made use of one fairly large colony of bats regularly. During that time he had never been able to determine where these bats—hundreds of *Myotis*—went to hunt for insects. Working with Greg Auger, who developed night-vision video methods that rendered not only the bats but also the insects visible in recordings and who actually had located the pond where these particular bats foraged, Griffin studied the relation between insect capture and the reliability of the "feeding buzz" in the terminal stage of aerial interception. He and Greg reported their findings at the North American Bat Research Symposium in Burlington, VT, in 2002.

Donald Griffin was a member of the National Academy of Sciences, American Academy of Arts and Sciences, American Philosophical Society, Animal Behavior Society, American Physiological Society, American Society of Zoologists, and the Ecological Society of America.

James A. Simmons, Department of Neuroscience, Brown University, Providence, RI 02912

Future Meetings and Events

June 12- 16, 2004

The 84th Annual Meeting of the American Society of Mammalogists will meet at Humboldt State University in Arcata, CA. For additional information visit the website at: http://www.humboldt.edu/~asm or the Society website at: www.mammalogy.org

July 6 -9, 2004

The **International Foundation for the Conservation of Wildlife**, in partnership with the French Ministry of Foreign Affairs, the National Museum of Natural History, CIRAD and the Office National de la Chasse et de la Faune Sauvage, is very pleased to announce the convening of the **6th International Wildlife Ranching Symposium**. The Symposium will be held at the National Museum of Natural History, in Paris, France, from 6 to 9 July 2004.
For further information and registration materials contact: igf@fondation-igf.fr

August (first week), 2004

A **"Bat Blitz",** co-sponsored by the Southeastern Bat Diversity Network will be held in the Piedmont region of North Carolina. Sites tpo be surveyed will be in the Uwharrie Naional Forest, the Pee Dee National Wildlife Refuge, Morrow Mountain state Park, ands Land Trust sites of Central North Carolina. For more information contact Mary K. Clark at: mkclark@aol.com

August 23 - 28, 2004

The **13th International Bat Research Conference** is planned to be organised in Poland from 23-28 August 2004. More information about the conference will is available at: http://www.miiz.waw.pl/IBRC also http://www.miiz.waw.pl/IBRC

September 17-19, 2004

A **Bat Conference organized by the Bat Conservation Trust** of the United Kingdom, will take place between 17th and 19th September at the University of Reading. More information will be available on our website: www.bats.org.uk from May/June onwards. Booking details aren't available yet,

October, 27 - 30, 2004

The **34th Annual North American Symposium on Bat Research,** will convene in Salt Lake City, Utah, October 27-30, 2004 Hosted by Michael Herder. For additional information see our web-site at http://www.nasbr.org

February, 2005 The Annual Meeting of the Colloquium on the Conservation of Mammals in the Southeastern United States and the Southeastern Bat Diversity Network will be held at Paris Landing State Park in Tennessee.
More information will be available in summer at: http://www.sebdn.org

August, 2005

The next **European Bat Research Symposium** will be held in Ireland in August 2005. More details will appear here as they become available.

October, 19 - 22, 2005

The **35th Annual North American Symposium on Bat Research,** will convene in Sacramento, CA, October 19-22, 2005. The symposium will be hosted by Winston Lancaster. For additional information see our web-site at http://www.nasbr.org

BAT RESEARCH NEWS

VOLUME 45: No. 2 SUMMER 2004

BAT RESEARCH NEWS

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Communications concerning feature articles and "letters to the Editor" should be addressed to Kurta, recent literature items to Kazial, conservation items to Morton, and all other correspondence to Griffiths.

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Front Cover Illustration

The cover logo was created by Levy Vargas (N. C. State Museum of Natural Sciences in Raleigh, NC) for the "Ouachita Mountain Bat Blitz - 2003." The logo shows the outline of the state of Arkansas, with the red bat (*Lasiurus borealis*) flying over the Ouachita Mountains and Ouachita National Forest, which was surveyed by volunteer bat biologists in August 2003. A report of this event, "Puttin' on the Blitz: Lessons Learned from the Ouachita Mountains Bat Blitz of 2003," can be found on p. 46 of this issue.

From the Editor

Dear Subscribers to *Bat Research News*,

As most of you already know, Roy recently "retired" as Managing Editor and Publisher of *Bat Research News* after serving in that capacity for 27 years. He has now passed this journal-newsletter onto me, this being my first issue as Managing Editor/Publisher. I thank all of you, and especially Roy, for allowing me the opportunity to do this.

I plan to continue the same "tried and true" tradition for *Bat Research News* as Roy has followed, although I do not have his managerial and publishing skills as yet. I apologize in advance for any errors made in the production of this issue and any mailings that I might inadvertently miss. I also apologize for my slowness in responding to emails, and my general tardiness in getting this issue to press. The turnover of *Bat Research News* has been a slow and almost overwhelming process for me. I ask for your patience and tolerance as I learn the skills necessary to be as successful at this position as Roy has been.

I am very pleased to announce that Dr. Karry Kazial (SUNY at Fredonia, Fredonia, NY) will be the new Editor for Recent Literature. Karry is very enthusiastic about accepting this new role, and I am confident that she will bring a new energy and point of view to *BRN*. Thank you, Karry, for agreeing to step into this role.

Dr. Allen Kurta of Eastern Michigan University (Ypsilanti, MI) and Patricia Morton of Texas Parks and Wildlife (Austin, TX) have agreed to stay on as Editor for Feature Articles and Editor for Conservation/Education, respectively. Both of them have been extremely helpful and supportive during the past few weeks, as I have worked to put this issue together. I thank both of them for their ideas, advice, and willingness to remain with *BRN* during this transition, I look forward to working with Al, Karry, and Pat in the coming years.

I also thank Dr. Thomas Griffiths for his support and "words of wisdom" as I worked on this issue of *BRN*. He, too, has given me extremely helpful advice, suggestions, and support during the past few months (as well as for the past 14 years).

And, of course, this issue could not have been possible had it not been for Dr. G. Roy Horst, former Managing Editor/Publisher of *BRN*, **retired** (the latter part of which he reminds me on an almost daily basis!). Thank you, Roy, for all the help you have given me during the past few months, for sharing your files, knowledge and expertise with me, and for continuing to answer all my questions. But most of all, Roy, thank you for your many years of service to *BRN* and to the NASBR. You are a ***very*** tough act to follow! I only hope that one day I will come close to achieving the same level of expertise and "class" that you have demonstrated during your time as Managing Editor/Publisher of *Bat Research News* (and Director of the NASBR). Enjoy your retirement, Roy, but I guarantee all of us will stay in contact with you!

All my very best wishes,

Margaret

Margaret A. Griffiths, Managing Editor and Publisher

History and Current Status of the Bat Banding Office, National Museum of Natural History

Suzanne C. Peurach

USGS Patuxent Wildlife Research Center, Smithsonian Institution, P.O. Box 37012, National Museum of Natural History, NHB 378, MRC 111, Washington, D.C. 20013-7012

History

Although several projects using bird bands to identify bats date from the early 1900s, the first long-term program for banding bats in North America began in the 1930s, with the work of Donald R. Griffin, Earl L. Poole and Charles E. Mohr. At that time, bird bands were sanctioned for use on bats by the Bureau of Biological Survey (U.S. Department of Agriculture), Section of Wildlife Surveys—a group that was stationed in the United States National Museum (now the National Museum of Natural History) of the Smithsonian Institution. The Bureau of Biological Survey began serving as a central clearinghouse for records and correspondence associated with bands issued for use on bats. Since that time, there have been several large-scale banding operations, such as those of Harold Hitchcock, Wayne Davis, and James Cope, as well as others that are listed among the annotated references at the end of this paper.

Requests for bat bands reached an all-time high in 1962, when 250,000 bands were issued (Greenhall and Paradiso, 1968). The American Society of Mammalogists officially endorsed the bat-banding program in 1964, and by 1971, over 2,000,000 bat bands had been provided to biologists (memorandum from Clyde Jones, Chief, Mammal Section, Bird and Mammal Laboratories, 2 June 1971). These banding projects contributed to many publications on the natural history of bats and provided longevity records for a number of species. The oldest bat recorded for North America, for example, is a little brown bat (*Myotis lucifugus*) that was at least 34 years of age when last recovered (Davis and Hitchcock, 1995). Banding permitted mapping of migration routes and calculations of migration distances (e.g., Villa R. and Cockrum, 1962). Long-distance flight records of 1,840 km for Mexican free-tailed bats (*Tadarida brasiliensis*—Glass, 1982) and 1,032 km for gray bats (*Myotis grisescens*—Gunier, 1971) were documented with banded bats. Other banding projects reported sex ratios, population sizes, and seasonal shifts in species composition within roosts (e.g., Hitchcock, 1965).

In June 1973, the Bird and Mammal Laboratories of the U.S. Fish and Wildlife Service, the successor of the Section of Wildlife Surveys, stopped issuing bands because overwhelming evidence indicated that activities related to handling and banding caused bat mortality. A memorandum by Clyde Jones, dated 7 September 1972, stated, "One of the major reasons for declines in bat populations is the disturbance of bats in roosts. Bat banding activities are a primary source of disturbance to bats. The indirect effects of handling and observer influence associated with bat banding activities are of greater magnitude than the direct effects." Even though a number of biologists continued to band bats with previously distributed bands, an unfortunate consequence of the decision to stop issuing bands was the near cessation of reporting of results of banding studies, including recoveries of previously banded bats. The Biological Survey Unit of the U.S. Geological Survey is the current successor to the Bird and Mammal Laboratories and, as such, continues to manage information about bat banding, although reports of recoveries have become uncommon. Our unit, however, continues to receive reports of recovered bat bands for which we have no original banding data on file.

Types of Bands

Aluminum bands were issued by the Bird and Mammal Laboratories, U.S. Fish and Wildlife Service (currently USGS Patuxent Wildlife Research Center, Biological Survey Unit) between 1932 and 1972, with a limited number issued for special projects in 1976. Three sizes of bands were commonly used—0, 1, and 2—and inscriptions on the inside and outside surfaces of the bands differed according to size of band and the changing name of our organization. Inscriptions typically included instructions to “NOTIFY” OR “WRITE” the “NAT. MUS.” or “F. & W. SERV.” in “WASH. D.C.” The band number always appeared on the outside of the band, whereas contact instructions usually appeared on the inside, except on size 2 bands, which were large enough to place all information on the outside. Figure 1 shows representative aluminum bands issued by the U.S. Fish and Wildlife Service.

The earliest bands used on bats actually were bird bands issued by the Bureau of Biological Survey. Bands were applied initially to the leg or foot of the bat until Trapido began banding bats on the forearm in 1939 (Greenhall and Paradiso, 1968.) Our oldest banding files list series of band numbers that are preceded by a letter, such as the C-, F-, and H- series of bands. Harold B. Hitchcock had experimental batches of bands manufactured in 1956 based on bands used by European researchers. These bands had rounded edges that could be bent to form a lipped contact surface (Hitchcock, 1957). Hitchcock reported that this type of band was superior to the American bird-band style previously used on bats and that it caused fewer injuries. Size 2-A wing clips were used by Hitchcock in 1960; these V-shaped aluminum clasps were inscribed with an A followed by a 3-digit number, and were designed to be pinched together on the wing membrane. In 1959, Hitchcock also used ear tags prefixed with an A, followed by a 4-digit number, but no examples of the tags have been located. Some biologists had their bands anodized with color to spot specific bats or groups of bats without having to recapture them. We have samples of returned bands that are yellow, green, white, and blue.

Current State of the Information

Information regarding bat banding and subsequent recovery is maintained in an extensive 3-by-5 card file that is organized by number of band. Individual cards may hold information for an individual bat or a large series of bats of the same species and gender, and from the same location and date. Estimates range from 300,000 to 600,000 records of individual bat-band numbers. Subsequent recovery data are annotated onto these cards and cross-referenced through correspondence files stored in our office. The correspondence contains information on original band placement, as well as subsequent recovery. Several attempts have been made to transfer this extensive card file to a computerized database; however, the task is daunting, and the necessary personnel and monetary resources have not been available.

We have reservations concerning the validity of some data in the bat-banding files. For example, we have several records of apparently duplicate band numbers. These duplicates are quite old and perhaps represent different types of bands, although the card file does not indicate how to distinguish them. Many recovery records do not indicate the physical condition of the bat at the time of recovery (e.g., living or dead). Another problem associated with the banding data is reliability of the field identifications. Although efforts were made to issue bands only to qualified specialists, identification of some species can be difficult. In addition, bands occasionally were issued to one person, who then passed them on to other people without informing our office;

Fig. 1. Representative aluminum bands issued by the United States Fish and Wildlife Service. Band sizes 0 and 1 have contact information on the inside (top) and the band number on the outside (bottom). Band size 2 shows information and band number on the outside of the standard (top) and lipped (bottom) band. End views of the standard size 2 (top), size 0 (center) and lipped size 2 (bottom) bands are on the right.

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consequently, we often lack information concerning who actually was involved with collection of the band-placement data and, especially, who provided the identifications.

Current Role of the National Museum

A major objective in providing this review is to make bat researchers aware that banding and recovery data continue to be recorded. Minimum information that we need from a banded bat includes band number, species identification, date and locality where the bat was banded or recovered, sex and reproductive condition, and the disposition of the bat (e.g., released, preserved as a voucher, found dead but fresh, found dead and mummified). If a banded bat is found dead, it should be deposited in a natural history collection, provided the specimen is legally salvaged and all permitting issues are addressed. Care should always be taken when handling ill or dead bats to prevent exposure to rabies virus or other pathogens. If a band that is not still attached to a bat is found, necessary information includes date, location, and circumstances in which the band was located (e.g., floor of cave, attached to wing bone, in tree hole, etc.). Additional information, such as where a bat was found, its parasites, behavior, and anything else of interest, is welcomed along with the recovery data. Banding and recovery data, whether current or dated, are still of great interest to researchers and will be integrated into the bat-banding files.

We believe that we have an obligation to receive information on bands issued by this office and to provide information from our files upon request. Although we do not intend to reactivate the banding program, the files that we maintain contain potentially valuable information, and we welcome discussion on how that potential might be realized. We also encourage interested persons to become familiar with our bat-banding files. The address for information regarding bat-banding data, recoveries, or correspondence is: Biological Survey Unit, Mammals, USGS Patuxent Wildlife Research Center, Smithsonian Institution, P.O. Box 37012, National Museum of Natural History, Room 378 MRC 111, Washington, DC 20013-7012.

Acknowledgments

This manuscript resulted from lengthy discussions and constructive criticism from many people, including A. L. Gardner, M. A. Howe, R. D. Fisher, R. P. Reynolds, and N. Woodman. I thank M. E. Gustafson and D. E. Wilson for reviewing the manuscript and providing helpful comments. Additional, historical, banding information was provided by B. Bacon, L. E. Ellison, M. E. Gustafson, and M. K. Klimkiewicz. L. Wolfe was instrumental in providing editorial improvements, and A. L. Gardner provided photographs of bat bands.

References Pertaining to Bat Banding in North America

Below is a partial list of references to published and unpublished literature concerning bats and bands issued by our office. Many references are annotated.

Allen, A. A. 1921. Banding bats. Journal of Mammalogy, 2:53–57. [Applied aluminum bird bands to the legs of four eastern pipistrelles (*Pipistrellus subflavus*) roosting on his porch in 1916 and recovered three in 1919 in the same place.]

Bonaccorso, F. J., and N. Smythe. 1972. Punch-marking bats: an alternative to banding. Journal of Mammalogy, 53:389–390.

Brenner, F. J. 1971. [Untitled comments.] Bat Research News, 12:2. [Banding of little brown bats and big brown bats (*Eptesicus fuscus*) in western Pennsylvania to investigate migratory behavior. Fred Brenner was issued 5,000 bands.]

Brownie, C., D. R. Anderson, K. P. Burnham, and D. S. Robson. 1978. Statistical inference from band recovery data—a handbook. United States Department of the Interior, Fish and Wildlife Resource Publication, 131:1–212. [Use of statistics for analyzing banding data from the perspective of the bird bander.]

Bruce, D. 1971. [Untitled comments.] Bat Research News, 12:38. [Comments about aggression in captive *Lasiurus* while working in southern Washington with Clyde Senger and students. Senger was issued 2,200 bands.]

Cockrum, E. L. 1956. Homing, movements, and longevity of bats. Journal of Mammalogy, 37:48–57.

Cross, S. 1971. [Untitled comments.] Bat Research News, 12:38. [When mist netting in southern Oregon, Stephen Cross captured nine species, including 66 banded bats. Cross was issued 2,300 bands, but correspondence indicates that most banding data were lost.]

Davis, E. L. 1968. Bats and bat-banding. Atlantic Naturalist, 23:209–210.

Davis, W. 1971. [Untitled comments.] Bat Research News, 12:6. [Notes on an eastern pipistrelle banded in Monroe County, West Virginia, and recaptured in Roanoke, Virginia. Wayne Davis was issued 87,000 bands, but our files indicate that some series of bands were transferred to Michael J. Harvey and David J. Fassler.]

Davis, W. H., and H. B. Hitchcock. 1965. Biology and migration of the bat *Myotis lucifugus* in New England. Journal of Mammalogy, 46:296–313.

Davis, W. H., and H. B. Hitchcock. 1995. A new longevity record for the bat *Myotis lucifugus*. Bat Research News, 36:6.

Easterla, D. A. 1970. [Untitled comments.] Bat Research News, 11:35. [Comments about behavior of a banded *Euderma* following release. David Easterla was issued 7,000 bands.]

Easterla, D. A. 1973a. Ecology of the 18 species of Chiroptera at Big Bend National Park, Texas. Part I. The Northwest Missouri State University Studies, 34:1–53.

Easterla, D. A. 1973b. Ecology of the 18 species of Chiroptera at Big Bend National Park, Texas. Part 2. The Northwest Missouri State University Studies, 34:54–165.

Elder, W. H., and W. J. Gunier. 1972. Improved tools for bat banders. Bat Research News, 13:14–19. [William Elder and Wilbur Gunier were issued 200 and 31,000 bands, respectively.]

Glass, B. P. 1958. Returns of Mexican free-tailed bats banded in Oklahoma. Journal of Mammalogy, 39:435–437. [Over 10,000 Mexican free-tailed bats were banded in Oklahoma. Recoveries included a band from an owl pellet as well as several from Texas. Bryan P. Glass was issued 76,000 bands.]

Glass, B. 1971. [Untitled comments.] Bat Research News, 12:37. [Data were reported for recaptured free-tailed bats, including dates and localities. Correspondence indicates that some bands were color anodized for different study years.]

Glass, B. P. 1982. Seasonal movements of Mexican freetail bats *Tadarida brasiliensis mexicana* banded in the Great Plains. The Southwestern Naturalist, 27:127–133. [A discussion of over 170,000 recoveries by Glass and his students over a 14-year period, including the long-distance record of 1,840 km.]

Goad, M. S. 1982. Sex ratios and summer roost site specificity of bats on the White River Plateau, Colorado. Unpublished manuscript. [A banding project involving six species in Colorado between 1981 and 1982. Bands were issued to Robert G. McLean in 1970 and transferred to M. Susanna Goad in 1981.]

Greenhall, A. M., and J. L. Paradiso. 1968. Bats and bat banding. Bureau of Sport Fisheries and Wildlife, Resource Publication, 72:1–48. [General information on bat banding, including a list of references for many species.]

Griffin, D. R. 1934. Marking bats. Journal of Mammalogy, 15:202–207. [General discussion of marking bats with tattoos or aluminum bands. Donald R. Griffin was issued 5,000 bands.]

Griffin, D. R. 1936. Bat banding. Journal of Mammalogy, 17:235–239. [Over 3,000 bats were banded in Massachusetts and Vermont, with over 700 recoveries. Griffin also discusses use of stains, tattoos, ear clips, and applying bands to wings or legs.]

Griffin, D. R. 1940a. Migrations of New England bats. Bulletin of the Museum of Comparative Zoology, 86:217–246.

Griffin, D. R. 1940b. Notes on the life histories of New England cave bats. Journal of Mammalogy, 21:181–187.

Griffin, D. R. 1945. Travels of banded cave bats. Journal of Mammalogy, 26:15–23.

Gunier, W. J. 1971. Long-distance record for movement of a gray bat. Bat Research News, 12:5. [Of 551 banded bats, there were 115 returns, with one bat located 1,032 km from release point. Card files indicated banding was done by Richard F. Myers and that some of Wilbur Gunier's original records burned. Myers was issued 11,000 bands, and Gunier, 31,000 bands.]

Gunier, W. J. 1971. Stress induced abortion in bats. Bat Research News, 12:4.

Gunier, W. J., and W. H. Elder. 1971. Experimental homing of gray bats to a maternity colony in a Missouri barn. The American Midland Naturalist, 86:502–506. [A sample of 437 bats were caught, banded, and released at different distances from a barn containing a maternity colony of ca. 15,000 gray bats. At least 25% of bats homed to the barn.]

Herreid, C. F., II., R. B. Davis, and H. L. Short. 1960. Injuries due to bat banding. Journal of Mammalogy, 41:398–400. [Report compares injury to *Tadarida brasiliensis* from bird bands and size 0 and 1 bat bands. Different levels of irritation were recorded, and a new model of band designed for bats reduced irritation and injury. Richard B. Davis was issued 500 bands;

Clyde F. Herreid II assumed Davis's banding activities and received 2,500 ear tags, as well as 4,000 lipped bands, which were later returned.]

Hitchcock, H. B. 1950. Sex ratios in hibernating bats. National Speleological Society Bulletin, 12:26–28. [Over 50,000 bands were issued to Harold B. Hitchcock between 1939 and 1962.]

Hitchcock, H. B. 1965. Twenty-three years of bat banding in Ontario and Quebec. The Canadian Field-Naturalist, 79:1–78.

Hitchcock, H. B. 1957. The use of bird bands on bats. Journal of Mammalogy, 38:402–405.

Hitchcock, H. B. 1971. [Untitled comments.] Bat Research News, 12:2. [A course taught by Hitchcock, entitled "A field study of the bats of Maine," is described. Course covered capturing, banding, and releasing bats from summer colonies.]

Hitchcock, H. B., R. Keen, and A. Kurta. 1984. Survival rates of *Myotis leibii* and *Eptesicus fuscus* in southeastern Ontario. Journal of Mammalogy, 65:126–30. [A rigorous analysis of banding and recovery data from 1941–1962. Males lived longer after banding than did females.]

Humphrey, S. 1970. [Untitled comments.] Bat Research News, 11:36. [A winter recapture program is described netting *Myotis lucifugus* in Illinois, with assistance from Harlan Walley. *Myotis keeni* also had been netted in winter. Stephen R. Humphrey was issued 27,000 bands, and Harlan D. Walley, 14,000 bands. A series of 1,000 bands was transferred to James B. Cope.]

Humphrey, S. 1971. [Untitled comments.] Bat Research News, 12:3. [List of bats banded in Oklahoma in 1969 and 1970, including ca. 1,800 cave bats, *Myotis velifer*.]

Humphrey, S. R., and J. B. Cope. 1976. Population ecology of the little brown bat, *Myotis lucifugus*, in Indiana and north-central Kentucky. American Society of Mammalogists, Special Publication 4:1–81. [A total of 71,706 bats was banded during all seasons of the year, with recapture of 10,760 individuals. James B. Cope was issued 68,000 bands, although 15,000 were later returned. Also see Humphrey, 1970].

Humphrey, S. R., and J. B. Cope. 1977. Survival rates of the endangered Indiana bat, *Myotis sodalis*. Journal of Mammalogy, 58:32–36. [Bands were applied to 9,059 *Myotis sodalis*, and banded individuals were recaptured 5,023 times over 23 years. Rates of survival, calculated from recaptures, differed between genders.]

Jones, C. [Undated]. The status of populations of bats in the United States. Unpublished manuscript. [Includes recommendations to review the bat-banding program, restrict bands to qualified biologists, and minimize disturbance of bats.]

Jones, C. 1971. [Untitled comments.] Bat Research News, 12:1. [Note describing a work in progress on bat-banding policy, as well as encouragement to supply banding data for a computerization project.]

Keen, R., and H. B. Hitchcock. 1980. Survival and longevity of the little brown bat (*Myotis lucifugus*) in southeastern Ontario. [Robert Keen provided the statistical analysis of Hitchcock's data. Males lived longer after banding than females.]

Martin, R. A., and B. G. Hawks. 1972. Hibernating bats of the Black Hills of South Dakota. Bulletin of the New Jersey Academy of Science, 17:24–30. [2,000 bands were issued to Robert A. Martin.]

Milstead, W. W., and D. W. Tinkle. 1959. Seasonal occurrence and abundance of bats (Chiroptera) in northwestern Texas. The Southwestern Naturalist, 4:134–142. [A reference collection of voucher skins was placed into the mammal collection at Texas Tech prior to banding. Our files indicate that W. W. Milstead banded for R. W. Strandtmann. Strandtmann and Tinkle received 5,000 and 10,000 bands, respectively.]

Mohr, C. E. 1936. Notes on the least brown bat, *Myotis subulatus leibii*. Proceedings of the Pennsylvania Academy of Science, 10:62–65. [First records of the small-footed bat for Pennsylvania, as well as bat-marking studies. Aluminum bird bands and ear tags were tested; ear tags were superior and used exclusively. Charles E. Mohr was issued 1,800 bands.]

Mohr, C. E. 1952. A survey of bat banding in North America, 1932–1951. National Speleological Society Bulletin, 14:3-13.

Mohr, C. E. 1972. The status of threatened species of cave-dwelling bats. National Speleological Society Bulletin, 34:33-47. [Includes discussion of injuries due to bands and calls for reduction in banding efforts.]

Moore, G. W. 2002. 30-year-old bat discovered in Maine. Caledonian Record, St. Johnsbury, Vermont. [Recovery of banded bat, with partly discernible number, in Maine. The reported number belongs to an *Eptesicus fuscus* banded in West Virginia, but the record is probably an error, because a series of *Myotis lucifugus* with similar band numbers were banded within the same mine.]

Moore, G. W. 2002. More on Maine bat. Caledonian Record, St. Johnsbury, Vermont. [Discussion, including excerpts from letter sent by Alfred L. Gardner, of earlier publication about 30-year-old, banded bat; see Moore, 2002.]

Paradiso, J. L. and A. M. Greenhall. 1967. Longevity records for American bats. American Midland Naturalist, 78:251–252. [Arthur Greenhall was issued 8,000 bands.]

Parmalee, P. 1971. [Untitled comments.] Bat Research News, 12:38. [Comments on banding at a hibernaculum of big brown bats for over 10 years. Paul W. Parmalee was issued 500 bands and, as noted in card file, also used bands not issued by this office.

Villa-R., B., and E. L. Cockrum. 1962. Migration in the guano bat *Tadarida brasiliensis mexicana* (Saussure). Journal of Mammalogy, 43:43–64. [Discussion of published observations, literature, and bat-banding evidence indicating that *Tadarida brasiliensis mexicana* is seasonally migratory, as well as estimated population sizes, sex ratios, and seasonal fluctuations. E. Lendell Cockrum was issued 16,000 bands, and Bernardo Villa-Ramirez, 25,000 bands.]

Foods of the Indian Flying Fox (*Pteropus giganteus*) in the Aravalli Hills, Rajasthan, India

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Introduction

The Indian flying fox (*Pteropus giganteus*) is one of the largest of bats. It is a colonial species that usually roosts in large well-established trees, which, in India, generally are located close to human settlements. The bats roost in a variety of trees, including *Ficus bengalensis*, *Ficus relegiosa*, *Madhuca indica*, *Mengifera indica*, *Phoenix sylvestris*, and *Tamarindus indica*. There is a little information on the seasonal food habits of the Indian flying fox, and this paper presents data on the types of food plants and plant parts eaten by Indian flying foxes, from 1994 to 2001, in the Kumbhalgarh Wildlife Sanctuary in the Aravalli Hills of Rajasthan, India. Our data were collected during a long-term eco-behavioral study on the Hanuman langur (*Semnopithecus entellus*).

Study Site and Methods

The Kumbhalgarh Wildlife Sanctuary is located between 20°5’ and 23°3’ N latitude and 73°15’ and 73°45’E longitude, ca. 200 km S of Jodhpur, in the west Aravalli Hills of Rajasthan, India. Total area of the sanctuary is 585 km^2, and altitude varies from ca. 275 to 1,150 m above sea level. KWS is characterized by three distinct seasons—winter, summer, and monsoon. During summer, air temperature fluctuates between 30 and 35°C, but may rise to 46°C during May and June. Mean ambient temperature in winter is 5°C, although it may fall to 2°C in December and January. Average annual rainfall is 725 mm, ranging from 950 to 403 mm (Chhangani, 2000).

During the study, a total 84 full-moon nights were spent in different seasons, and overnight observations were made from elevated platforms on 15 trees that were located in different parts of the sanctuary, while observing Hanuman langur-predator interactions. The crown density method (Marsh, 1981) was used for studying the phenology of plants. After locating a feeding bat, data were collected, with the help of binoculars, by scan and *ad lib.* sampling methods (Altmann, 1974), which was sufficient to determine the species of plant and plant part that was being eaten.

Results and Discussion

Ten colonies of the Indian flying fox were observed, and each of these was located from 4 to 45 km outside the sanctuary. Bats left the roosts ca. 20–50 min after sunset, and variation in departure time may have depended on distance from the roost to the feeding site. The direction that the bats took varied with season and apparent availability of food.

The Indian flying fox near Kumbhalgarh Wildlife Sanctuary fed on 26 species of plant, including 19 natural and 7 cultivated plants. The diet comprised flower buds, flowers, unripe fruits, and mature fruits, and when food was scarce during times of drought, the bats also fed on young leaves and shoots (Table 1). Cultivated plants were consumed more during summer and monsoon months, when non-cultivated plants produced fewer flowers and fruits. Even though the Indian flying fox ate cultivated plants, this bat never raided local plantations of nimbu (*Citrus medica*), anwala (*Cassia auriculat*) and karonda (*Carissa congesta*). In the non-fruiting season, the Indian flying fox also is known to consume soft leaves and twigs of samel (*Bombex ceiba*) and imli (*Tamarindus indica*) trees (Sinha, 1986). Although Prakash (1961) reported many of the same species of plant as food items for the Indiana flying fox in the desert area of Rajasthan, our study is the first to record feeding based on season and plant parts.

Acknowledgments

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Marsh, C. 1981. Diet choice among red colobus (*Colobus badius rufomitratus*) on the Tana River, Kenya. Folia Primatologica, 35:147–178.

Prakash, I. 1961. Taxonomic and biological observations on the bats of the Rajasthan desert. Records of the Indian Museum, 59:149–170.

Sinha, Y. P. 1986. The Bats of Bihar: taxonomy and field ecology. Records of the Zoological. Survey of India, Miscellaneous Publications, Occasional Papers, 77:1–60.

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Table 1. List of plants and their parts[a] consumed in different months by *Pteropus giganteus* near the Kumbhalgarh Wildlife Sanctuary in the Aravalli Hills, Rajasthan, India.

Local name	*Scientific name*	*J*	*F*	*M*	*Ap*	*M*	*Jn*	*Jl*	*Au*	*S*	*O*	*N*	*D*
A. Noncultivated plants													
Aam	*Mangifera indica*				FL	FL, UF	UF						
Bargad	*Ficus benghalensis*	RF		UF	RF				UF	UF	RF	RF	RF
Ber	*Ziziphus mauritiana*	RF	RF				ST	ST				RF	RF
Dhawra	*Anogeissus pendular*								UF	RF			
Gundi	*Cordia gharaf*				FL	UF	RF						
Gular	*Ficus racemosa*			YL	UF	RF	RF			UF	RF		
Imli	*Tamarindus indica*	UF	UF	YL, RF	YL		ML				FL	FL	FL
Jamun	*Syzygium cumini*				YL, UF	UF	UF, RF	RF	RF				
Jhinjha	*Bauhinia racemosa*					YL		FL	FL	UF			
Khajoor	*Phoenix sylvestris*						UF	RF	RF				
Mahua	*Madhuca indica*			UF	RF	UF							
Neem	*Azadirachta indica*							UF	RF				
Palas	*Butea monosperma*		FB	FB		FL							
Pepal	*Ficus religiosa*			YL	UF	RF					RF	RF	
Sitaphal	*Annona squamosa*					YL	YL			UF	RF		
Samel	*Bombex ceiba*		FB	FB, FL	FL	YL, UF	YL, RF						
Timru	*Diospyros melanoxylon*					UF	RF						
Safed dhawra	*Anogeissus latifolia*								RF	RF			
Safeda	*Eucalyptus camaldulensis*					FL							

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Local name	*Scientific name*	*J*	*F*	*M*	*Ap*	*M*	*Jn*	*Jl*	*Au*	*S*	*O*	*N*	*D*
B. Cultivated plants													
Amrood	*Psidium guajava*										FL	UF	
Anar	*Punica granulatum*									FL	FL, UF	RF	
Gunda	*Cordia dichotoma*				FL	UF	RF						
Kala	*Musa paradisiacal*					UF	UF, RF	RF	RF				
Makka	*Zea mays*									UF	RF		
Papita	*Carica papaya*				FL	UF							
Shehtut	*Moruc australis*					UF	MF						

[a]YL = Young leaves; ML = Mature leaves; FB = Flower buds; FL = Mature flower; UF = Unripe fruits; and RF = Ripe fruits.

Letters to the Editor

Editor's Note: Unlike technical articles, letters are not peer-reviewed, but they are edited for grammar, style, and clarity. Letters provide an outlet for opinions, speculations, anecdotes, and other interesting observations that, by themselves, may not be sufficient or appropriate for a technical article. Letters should be no longer than two manuscript pages and sent to the Feature Editor.

Puttin' on the Blitz: Lessons Learned from the Ouachita Mountains Bat Blitz of 2003

On 4–6 August 2003, the U.S. Forest Service (Ouachita National Forest), Arkansas Game and Fish Commission, and the Southeastern Bat Diversity Network sponsored the Ouachita Mountains Bat Blitz on the Ouachita National Forest in western Arkansas. Like the first bat blitz held in the Great Smoky Mountains National Park in 2001, the purpose of this project was to bring together bat specialists for several days of capturing bats in an area that had not been surveyed, thereby providing important information on local bat distribution, and to have a good time working with people that usually only meet during conferences. Other scientists interested in gathering additional data (e.g., feces, parasites, and DNA) from captured bats, but who are not bat biologists themselves, also were invited to attend to take advantage of an opportunity to handle a large number of bats of different species in a short period.

Initial discussions of the Blitz began in mid-2002, but planning did not really begin until early 2003, when three Ranger Districts agreed to set aside funding to support the Blitz. Camp Clearfork, a group recreation facility operated by the Forest Service, was chosen as Blitz headquarters. The camp featured rustic cabins with bunks, toilets, showers, and a large dining hall and kitchen, and the site was available for use at no charge for this event. A Forest Service volunteer offered her services as cook, with the Southeastern Bat Diversity Network providing funding for food and incidental expenses. Each participant was charged a registration fee by the Southeastern Bat Diversity Network to cover these costs, with participants eventually being reimbursed for their registration fees by the Forest Service through signed, individual volunteer agreements.

In spring 2003, we began to publicize the Blitz through notices in *Bat Research News*, internet discussion groups, a presentation at a meeting of the Southeastern Bat Diversity Network, and other means, and we invited biologists to register for the event. Participants were asked to provide information on the type of equipment they could bring to the Blitz (e.g., mist nets, harp traps, high-net systems, etc.), if they would be collecting additional information (e.g., DNA samples, hair, blood, feces, parasites, etc.), and whether or not they would like to collect voucher specimens. Potential participants were provided information on the study area, local attractions, and safety considerations and were kept notified of developments through e-mail.

About 2 months prior to the Blitz, we met with the wildlife biologists assigned to the Ranger Districts upon which we would be working to discuss capture-site selection. We described typical mist net sites, such as stream corridors, underneath bridges, over small ponds, and at portals of abandoned mines, and we spent half a day looking at possible sites with them so that they understood the characteristics that we look for when selecting net sites. At this time we expected enough participants to form 10 teams, each of which could net one site per night for 3 days, and we asked each of the Districts to develop a list of potential survey sites for use during the Blitz. All proposed sites were then inspected by an experienced bat biologist, and by the time of the Blitz, we had a list of 39 acceptable sites. These sites were then given priority rankings, based on requests from District biologists and a desire to spread the sampling effort across as large an area as possible while sampling each District equally.

Thirty volunteer biologists from nine different states, primarily from the Southeast, and seven personnel from the Arkansas Game and Fish Commission and the Ouachita National

Forest participated in the Blitz. After the volunteers arrived, group leaders were chosen based on their experience and possession of the necessary capture equipment. Six to eight groups went out each night, and at the end of the Blitz, a total of 209 bats of five species were captured at 22 different locations. Additionally, 85 hair samples and 82 DNA samples were taken for future studies of genetics and migration, 17 blood samples were taken for examination for hematozoans, 12 fecal samples were collected to determine parasite presence, and 8 voucher specimens were retained for deposit in two natural history museums.

The Public Affairs Coordinator of the Arkansas Game and Fish Commission arranged for seven television stations and the statewide newspaper to send representatives to participate in the Blitz on one evening that was designated as "media night." After the media arrived at Camp Clearfork, they were given a briefing on the purpose of the event, as well as general background information on the bats of Arkansas so that they could ask informed questions during their interviews. For the most part, each station went out with its own group of bat biologists, which allowed them to have an "exclusive" take on the event, and other experts were available for additional interviews later that night and for four live television broadcasts during the following morning. This media event was part of a regular series of outings with Commission biologists that have been taking place for a number of years, with this occasion setting a record for television station attendance.

The total cost to sponsor the Bat Blitz was $8,060, including the indirect costs of not renting Camp Clearfork to a paying group and not requiring each biologist to pay $50 for a state scientific collection permit. We calculated that benefits to the Forest Service were $45,392, based on the cost of salary, per diem, and other expenses that would have been incurred by that agency if the netting had been conducted by Forest Service employees with similar skills and experience. Thus, the sponsors received a total of $5.60 in benefits for every $1 invested in the project.

To aid in organization of future blitzes, we offer seven comments/suggestions, based on lessons learned from the Ouachita Mountains Bat Blitz of 2003. 1) Having all biologists stay at a centralized location greatly aided in promoting a sense of community among the group and encouraged sharing of information among groups. 2) Having all trap sites inspected by an experienced bat biologist was critical to ensuring excellent trapping success. 3) Not all netting sites are equidistant from headquarters, and increased travel time to more distant locations should be factored into daily schedules to insure that nets are set up on time. 4) A map and/or driving directions were prepared for each net site so that participants unfamiliar with the area could locate the sites with minimum effort. 5) Although this event was intended primarily for experienced mist-netters, a significant number of participants had never used this type of equipment before, so a short training session during the first day of the Blitz would have eased difficulties in setting up the nets that first night. 6) Scientists interested in collecting additional information from bats should be asked to give a short presentation on their project and train participants in their appropriate collection techniques to maximize the number of samples that could be taken. 7) Results should be reviewed daily in a short, formal session to ensure that new tips or techniques are spread to the entire group.

We thank all Blitz participants for volunteering their time to come to Arkansas, and we strongly encourage others to organize similar events in other states.

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Abstracts of Papers Presented at the 2nd Bats and Forests Symposium and Workshop Held March 9-12, 2004 in Hot Springs, Arkansas

The abstracts are listed in alphabetical order by first author.

Foraging Habitat Use by *Lasiurus borealis, Myotis septentrionalis,* and *Myotis grisescens* in the Central Hardwood Region

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Forest bats use forest resources at micro-site (roost), site (patch) and landscape (foraging) scales. By quantifying resource use over time and space, resource selection models provide insight into how species meet their life requirements. Using mobile and stationary radio-telemetry approaches combined with acoustic monitoring, we obtained roosting and foraging data on 60 *Lasiurus borealis*, 35 *Myotis septentrionalis*, and 30 *Myotis grisescens* during lactation at 3 spatial scales. We addressed issues of telemetry error and habitat analysis method selection. We used polytomous logistic regression, utilization distribution and compositional analysis to evaluate habitat use. *Myotis septentrionalis* were found to forage in areas up to 4 km from their roost site. *Myotis grisescens* routinely foraged 32 or more km from their maternity roost and *Lasiurus borealis* were found to forage up to 10 or more km from their roost site. Information on movement patterns, habitat composition of foraging areas and timing of foraging will be presented.

Selection of Day Roosts by Three Species of Bat at Multiple Spatialscales in Managed Forests in Western Oregon

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We studied selection of day roosts by female and male long-eared myotis (*Myotis evotis*), female long-legged myotis (*Myotis volans*), and female big brown bats (*Eptesicus fuscus*) in the Oregon Cascades from 1999 to 2001. Our objectives were to determine characteristics of structures used as day roosts and factors influencing selection of roosts at multiple spatial scales. We attached radio transmitters to 163 bats: 50 female big brown bats, 28 female long-eared myotis, 31 male long-eared myotis, and 54 female long-legged myotis. We located 460 roosts via radio-telemetry and their locations were recorded using GPS. Random structures were sampled at points located within 4.8 km of each capture site; the 7,238-ha landscape within 4.8 km of a capture site was considered to be available habitat, based on an assumption that a bat captured and radio-tagged at a capture site had equal chance of flying any direction up to 4.8 km to select a roost structure. We assessed characteristics of roosts and random structures at multiple spatial scales using two approaches. First, at each roost and random structure, we measured characteristics of the structure and the immediate context in which it occurred. Second, we used GIS to evaluate the landscape context of each roost and random structure. At small and intermediate spatial scales, snags selected as day-roosts by female big brown bats and long-legged myotis were larger in mean diameter than were randomly available structures. In contrast, mean diameters of snags used by male and female long-eared myotis were less than those used by other species and randomly available snags. Mean heights of snags used as day roosts by female big brown and long-legged myotis were similar to that of randomly available snags, but

mean heights of snags used by male and female long-eared myotis was less than the mean of randomly available snags. Snags used by females of all 3 species and male long-eared myotis had more snags within 20 m than did randomly available snags. At broad spatial scales, results of resource selection models indicate that used sites differ from random sites with respect to a number of landscape-scale variables, including the total amount of snags in the landscape. Our results suggest that bats respond to characteristics at multiple spatial scales, and that conservation efforts should take this into account. Forest management efforts that focus unduly on one scale while ignoring others may be ineffective in achieving conservation objectives.

Habitat Use by Day-roosting Female Long-legged Myotis (*Myotis volans*) in Ponderosa Pine Forests

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We studied snag and stand-level habitat use by day-roosting adult female *Myotis volans* in four multiple-ownership ponderosa pine (*Pinus ponderosa*) forested watersheds east of the Cascade crest in Washington and Oregon, during 2001-03. We radio-tracked 87 bats to 195 snag roosts and 34 rock crevices over 842 roost-days. Bats changed roosts every 2.7 ± 0.16 days and used 3.6 ± 0.34 roosts during the 9.7 ± 1.12 days they were tracked. Roosts were 2.0 ± 0.10 km from capture sites and bats moved 1.4 ± 0.11 km between successive roosts. Radiotagged bats re-used 28.2% (range 13.8 - 34.3%) of roost snags within each season and 4 roosts used in 2001 (5.8%) were re-used in 2002. Six bats (6.9%) day-roosted in rock crevices exclusively and nine bats (10.3%) used snags and rock crevices. Most bats (82.8%) day-roosted in snags exclusively and most roost snags were thick-barked *P. ponderosa* (52.8%) or thin-barked *Abies grandis* and *A. concolor* (37.9%). Flyout counts revealed that bats roosted primarily under exfoliating bark and that 98 snag roosts (52%) were solitary roosts and 28 (14%) housed > 50 bats. Ninety-three percent of roost snags that housed ≥ 50 bats (i.e., large-flyout roosts) were *P. ponderosa* and 96.4% were thick-barked species (i.e., *P. ponderosa* and *L. decurrens*). Large-flyout roosts (n = 28) were larger, taller, and retained more bark and exfoliating bark than roosts that housed < 50 bats (n = 164), which were also larger, taller, and retained more bark and more exfoliating bark than random snags (n = 160). The difference between snag height and canopy height was greater for roost snags than for random snags. Roost snags were nearer other snags, located in areas of greater snag density, greater snag basal area, greater basal area of snags > 25cm diameter, and lower in elevation than random snags. Bats that were pregnant at the time of transmitter attachment day-roosted in snags with thin bark, primarily *Abies* spp., for longer periods than in snags with thick bark (3.3 ± 0.42 vs. 2.4 ± 0.29 days). Lactating bats day-roosted in snags with thick bark, primarily *P. ponderosa*, for longer periods than in snags with thin bark (2.7 ± 0.42 vs. 1.9 ± 0.20 days). We recommend that effective forest management for reproductive female *M. volans* should ensure the continued availability of both habitat components.

Day Roosting Ecology of Bark and Cavity Roosting Forest Bats: A Synthesis

Robert M. R. Barclay and Allen Kurta, Department of Biology, University of Calgary, Calgary, AB (RB); Department of Biology, Eastern Michigan University, Ypsilanti, MI (AK)

We synthesize information regarding roost selection and roosting behavior of forest-dwelling bats that roost in tree cavities and under bark. Reproductive females frequently form aggregations (maternity colonies) and most research has focused on them. Regardless of roost structure or the species of tree, maternity roosts are typically in large, early decay-stage trees

with relatively open canopies and low amounts of surrounding clutter. Older forest stands thus provide greater numbers of potential roosts. Because trees decay at different rates and in different ways, not all species provide equal roosting opportunities. Some species of bats appear to favor either bark or cavity roosts, while others are more flexible, although there are relatively few studies of the same species in different forest types across their range. Maternity groups switch roosts on a regular basis and although such groups are cohesive and occupy a home range encompassing a number of roosts, all individuals do not roost together every day. Reasons for roost switching are still not understood. Reuse of particular roosts from year to year appears to vary, perhaps depending on the decay rate of the particular tree species. Although much less is known about the roosting behavior of males and non-reproductive females, they appear to select roosts with different characteristics than those used by maternity groups. While warm roosts are important to reproductive females and their young, males and non-reproductive females may prefer cooler roosts. This difference in roost selection, and the fact that reproductive females switch roosts within a season, requires that management occur at a landscape scale, rather than focusing on individual trees.

Bats Respond to a Budworm Outbreak

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Because they eat large numbers of insects, bats may play a role in limiting populations of night-flying forest pests. Pest outbreaks represent dense patches of prey that may influence what bats eat, and where and when they choose to forage. We investigated the predator-prey interactions of bats and western spruce budworm (*Choristoneura occidentalis*, Lepidoptera: Tortricidae), in southern interior British Columbia, Canada. We predicted that bats would respond to a budworm outbreak by eating more moths (a functional response) and by foraging more in outbreak areas (an aggregative numerical response). We compared bat foraging behavior in both outbreak and non-outbreak areas, before and during the budworm moth flight period. Bat activity levels, bat diets and insect abundance were assessed in each of the four treatments using Anabat detectors, feces analysis and insect traps. Bats fed on budworm and responded to the budworm outbreak by increasing their moth consumption, indicating a functional response. Western long-eared bats, *Myotis evotis*, showed the strongest functional response. Analysis of overall bat activity did not show an aggregative numerical response at the community level; however, identification of bat passes to species or species groups will be informative. Western spruce budworm moths appear to be an important prey item for bats, and there is also evidence that bats prey on budworm caterpillars. Data from this study will be used to estimate the potential economic impact of bat predation on western spruce budworm.

Fire Ecology Of Bats In Temperate Forests

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Currently, there are few studies that examine the effects of forest fire on bat communities. Forest fire alters habitat, which may influence bat foraging activity and roost site selection. We recently completed the third year of a 5-year study that examines the effects of a 2000 forest fire on foraging assemblages and roost site selection in a New Mexican bat community. Foraging bat assemblages were assessed using mist-netting and ultrasonic detectors located in burned and unburned forest stands. To date we have found significantly higher bat diversity, species-richness, and abundance at net sites in unburned areas. Radio-telemetry was has been used to study maternity roost selection by two species of bats, *Eptesicus fuscus* and *Myotis volans*. Roosts sites are non-randomly distributed along southeast facing slopes and roost trees occur in more open stands than expected by chance. Although forest fire appears to have a dramatic effect on the distribution of the foraging bat community, it is unclear at this time what effect, if any, fire has on maternity roost selection.

Forest Dwelling Bats and Metal Contaminants: Are Bats at Risk?

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Forest dwelling bats often roost and forage in close proximity to permanent water bodies, which in South Carolina are often contaminated from industrial effluents, agricultural runoff, and urban development. Heavy metals in the environment, such as lead and mercury, can be problematic to wildlife but are often overlooked in conservation efforts for North American bats. To determine whether metal contamination may be impacting forest dwelling bats, the levels of the following ten trace elements: aluminum, arsenic, chromium, copper, mercury, lead, nickel, zinc, selenium, and cadmium were measured in the hair of three common foliage roosting bats, *Lasiurus borealis*, *Pipistrellus subflavus* and *Eptesicus fuscus*, in the Piedmont region of South Carolina. Levels of lead and mercury were elevated in certain bats, and may be having adverse effects. However, further monitoring is required to evaluate the population level impacts of metals on bats. In summary, forest managers should include regular contaminant monitoring of heavy metals in bats.

Wetland Restoration for Bat Habitat Improvement in Forested Areas

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Ridge top wetlands have become favored locations for biologists to sample bat populations in forested environments. A total of 9 bat species, including the federally endangered Indiana bat, *Myotis sodalis*, and Virginia big-eared bat, *Plecotus townsendii virginianus*, are regularly captured in mist nets set over ridge top wetlands on the Daniel Boone National Forest in Kentucky. These wetlands have also been found to provide habitat for species such as the marbled salamander, *Ambystoma opacum*, wood frog, *Rana sylvatica*, and fairy shrimp, *Eubranchipus sp*. A majority of the natural wetlands once found on ridge tops in Eastern Kentucky were drained beginning in the 1800's, leaving behind a now forested landscape that was greatly changed by early farmers. Recognizing the importance of wetlands to vertebrates and invertebrates, USDA Forest Service and Kentucky Department of Fish and Wildlife Service personnel have restored or created more than 1,000 ephemeral and permanent water wetlands on ridge top locations in Eastern Kentucky since 1990. Little information is available on how to restore or create ridge top wetlands for bats and other forest species. More than one-half of all wetland restoration projects fail because sites fail to develop the hydrologic regime necessary for supporting aquatic life. It is now possible to construct a ridge top wetland that looks and functions like a natural wetland. Techniques developed and tested on the Daniel Boone National Forest produce wetlands with desired hydro-periods, aquatic vegetation and animal life. Examples of how wetlands have been established on ridge top locations using heavy equipment and with hand tools will be given. Factors to consider when selecting wetland restoration sites and in choosing construction techniques will be shown for areas of drained and saturated soils.

Participants will see how wetland establishment projects can now be considered in forested or open areas, on vast expanses of public land or even adjacent to school grounds for outdoor classrooms. How new federal programs such as the Landowner Improvement Program, Wildlife Habitat Improvement Program, and Wetland Reserve Program can be used to fund wetland establishment projects that emphasize bat habitat needs will also be described.

Mine Closures Protect Forest Bats, and Provide a Protected Surrogate Habitat for Cave Adapted Species.

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There is a close association between bats and abandoned mines. More than half of the forty-three species of bats found in the United States utilize mines for hibernation, maternity roosts, day roosts, or night roosts. The mines at Rush are known to provide roost habitat for two federally endangered bat species, the gray bat (*Myotis grisescens*) and Ozark big-ear bat (*Corynorhinus townsendii ingens*). Three other forest bats, the eastern pipistrelle (*Pipistrellus subflavus*), northern long-ear bat (*Myotis septentrionalis*), and big brown bat (*Eptesicus fuscus*) also utilize these mines. Biological inventories of some of the mines in the district have uncovered troglobitic species. These mines may provide the same ecological functions as naturally occurring limestone caves. A study currently underway is comparing the ecological relationships between abandoned mines and caves. This study will examine the terrestrial communities of abandoned mines and caves, the environmental characteristics, and the relationship between environmental characteristics and biodiversity metrics. The mines and associated development at Rush represent a significant industry that was once active in this part of the Ozarks. At the peak of the mining period, Rush had a population of several thousand with ten mining companies working its narrow confines. In 1987, a total of 1300 acres, in and around Rush, was listed on the National Register of Historic Places as a Historic District. Cultural resources in and around the mines include living quarters, stores, a blacksmith shop, a smelter, mill and tramway foundations, winches, ore carts, rails, air compressors, drilling machines, air tanks, and numerous other artifacts. They also include tally marks and historic signatures smoked on the walls. Of the sixty-seven mine openings identified for closure, twenty have been closed to-date using bat gate closures. With few exceptions, these closures have prevented unauthorized human access to the interior of these mines. They have protected bats and other species from disturbance, and protected other natural and cultural resources.

Spring Roosting Ecology of Female Indiana Bats (*Myotis sodalis*) in the Northeastern United States

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While extensive effort has been directed towards roosting ecology of the federally endangered Indiana bat (*Myotis sodalis*) during the maternity season, little attention has been paid to its spring roosting ecology. In April 2002, we captured Indiana bats as they emerged from the species' northeastern most hibernaculum in northeastern New York. Bats were sexed, weighed, measured, and banded with an aluminum band. Using surgical glue, 0.50-gram radio transmitters were attached to the back of 19 female bats. An airplane was used to gain approximate locations of transmittered bats and ground tracking was used to locate roost sites. Thirty-nine roost trees in the Lake Champlain Valley of New York and Vermont were used for 224 bat days (i.e., 1 bat located for 1 day equals 1 bat day). Distance from the hibernaculum to roost trees ranged from 14.6 to 40.0 km (mean = 26.9 km). Shagbark hickory (*Carya ovata*) was used most commonly (33.3% of all trees, 39.7% of all bat days) of 11 tree species. Roost trees have a mean diameter of 45.6 cm, were 18.9 m tall, and had high levels of sun exposure. Roost trees were located in 13 areas that contained 1 to 5 roost trees each. Roost switching was uncommon, with an average of 1 switch every 4.85 days (range 1.35 - 16). Exit counts revealed 0 to 45 bats emerging. Despite multiple nights of below 0 ^{O}C weather, movement of bats (based on exit counts or movement among roost trees) was documented throughout the study. These results reveal that Indiana bats were traveling a short distance to summer maternity range and were present in the area of their maternity range in mid-April. Use of dead or dying trees with high degree of solar exposure as roosts during spring was similar to roost trees used during summer throughout its range; indeed, some trees were used during both spring and maternity season. Data from this study will allow land managers to provide appropriate roosting resources for female Indiana bats during this period of depleted energy resources and limited insect abundance, thereby aiding in the conservation of this species.

Day Roosting Ecology of North American Foliage-roosting Bats

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Foliage-roosting bats are unique because they use the foliage of living trees extensively as roosts during all or part of the year. In North America, seven species of *Lasiurus* including *L. blossevillii, L. borealis, L. cinereus, L. ega, L. intermedius, L. seminolus,* and *L. xanthinus,* use foliage throughout the year while *Pipistrellus subflavus* only uses foliage during the summer months. The roost type used differs not only by region but also by species within the same region. We reviewed the general roosting ecology of all North American foliage-roosting species and summarized the characteristics of roosts used at multiple spatial scales. Specific topics discussed include tree species used, structural characteristics of roosts, spatial relation of roost to resources, stand composition and structure, forest type, and landscape structure of roosting area. Also when available, information on the importance of roost selection relative to threats of predation and thermoregulatory requirements are given.

Roost Resource Partitioning among Three *Myotis* Species in Pinyon-Juniper Woodlands of New Mexico

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Although many researchers have examined roost ecology of individual bat species in western forests, few have simultaneously studied and compared two or more species in one habitat. Thus, we know little about community-level roost ecology of bats (e.g., are roost trees are limiting, do species compete for roosts, are resources are partitioned among species, etc.). In this study, I compared roost selection and behavior of *Myotis evotis, M. volans,* and *M. thysanodes* in pinyon-juniper woodlands of west-central New Mexico. I found compelling evidence for roost niche

partitioning among these 3 species. From 1995-1997, field crews and I radiotracked 58 reproductive female bats of these species (22 *M. evotis*, 17 *M. thysanodes*, and 19 *M. volans*) and located 111 day roosts in pinyons (*Pinus edulis*), junipers (*Juniperus* spp.), and ponderosa pine (*P. ponderosa*). Reproductive females of *M. evotis* roosted solitarily (only 14% of bats tracked to colonies), switched roosts frequently, and primarily used junipers (73.41 ∀ 7.86% of trees used, n = 21 bats). In contrast, reproductive females of *M. thysanodes* tended to roost in colonies (88% tracked to colonies), stay in one location, and roost in ponderosa pine (80.39 ∀ 8.48%, n = 17 bats). With behaviors intermediate to the latter extremes, *M. volans* used both colony and solitary roosts (44% tracked to colonies), switched roosts frequently, and used mostly pinyon (56.32 ∀ 8.91%, n = 19 bats). Although each tree species was used by more than one bat species, roosts of each bat species could be distinguished by either height or decay stage. Results of this study show that bat species within a particular habitat may occupy different roost niches and that a single, generalized roost profile (e.g., large diameter conifer snags in early stages of decay) is not possible in some forest types.

Bat Assemblages in Bottomland Hardwood Forests in the Southeastern United States
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The diversity of bat assemblages differs markedly within forested areas. Variation in that diversity, and in the occurrence of rare species within different areas, results from a range of factors. Of these factors the habitat features in a given area are among the most important components affecting species richness and the occurrence and abundance of individual species in that area. For bats, studies are lacking that address the specific factors that affect the composition of species assemblages in forests. From 1994 to 2002 the staff of the N. C. State Museum of Natural Sciences conducted a number of bat surveys in bottomland hardwood forests in three southeastern states (VA, NC, SC). The results of these studies indicate predictable patterns of bat assemblages related to habitat features. In our study sites the composition of species assemblages ranged from those with a small number of species that are wide-ranging (species that are found across much of North America) to larger assemblages of species that include both wide-ranging common bats and rare species that are found only in the southeastern states. Important habitat features that were associated with this variation were the dominant tree species in the site and forest structure. These findings have implications for landscape scale management for bats in bottomland hardwood forests, and such data can be used to develop meaningful indicators of habitat quality and in planning conservation priorities for large landscapes.

Migration and the Use of Autumn, Spring, and Winter Roosts by Forest Bats
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Compared to the tremendous progress made during recent years in determining the importance of trees to bats during summer, our understanding of forest use during other seasons is inadequate. However, certain patterns are apparent from the fragmentary information available on the autumn, winter, and spring use of roosts by bats inhabiting forests. Bat species that use trees as roosts can be categorized into two general groups: those that use trees in summer and move to subterranean sites during winter ("cave bats") and those that use trees as roosts year-round ("tree bats"). Many species of cave bats make local, directionally scattered migrations from their summering grounds to suitable sites where they hibernate throughout the winter. Tree bats that seasonally occupy northern regions tend to make longer, latitudinal migrations to areas where they can overwinter in trees without continuous exposure to freezing temperatures. Information pertaining to the winter roosting needs of cave bats is plentiful, but data on the winter behaviors and habitat requirements of tree bats are sparse. Evidence indicates that tree bats, which typically roost alone or in small groups during summer, form larger aggregations during migration. Migratory behavior of tree bats apparently differs between spring and autumn, as most encounters with migrating individuals occur during the latter season. Roosts used by tree bats during migration vary, although quantitative studies are lacking. Despite potentially long-distance seasonal movements, several bat species appear to migrate back to the same roosts in trees year after year. Considering the potential hazards of migration and reliance on trees, future conservation and management efforts will likely benefit by supporting research into the "off-season" use of forests by bats.

Eastern Red Bat (*Lasiurus borealis*) Habitat Use in Actively Managed Forested Landscapes
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Much of the southeastern United States is losing forested area because of increased urbanization and associated habitat loss. The Virginia Piedmont, however, has not been developed or converted as rapidly and thus provides an interesting opportunity to explore habitat use of native species. The forests of the Piedmont consist of a mix of seral stages and include hardwood, mixed pine-hardwood, and pine-dominated cover types; some large areas of this forested region are managed by federal, state, and industrial stewards. Eastern red bats (*Lasiurus borealis*) are one of three tree-roosting bat species known to occur in the forests of the Piedmont, but little is known about their roosting habits due to their solitary nature. Previous studies indicate that red bats typically roost in larger diameter hardwoods, however, more recent research suggests that roosting red bats also frequently utilize conifers. To understand how red bats use the varied forests of the Piedmont, we designed a project to describe habitat use by lactating females. Our objectives included both locating roost sites and quantifying roost-site and roost-patch characteristics. Using 0.38-gram radio transmitters, we tracked 13 bats in June and July 2003. We located day roosts of each bat and quantified the following roost-site characteristics: tree height (m), height to base of live crown (m), diameter at breast height (cm), aspect, and roost tree condition. In addition to roost-tree characteristics, we quantified roost-patch (0.04 ha) characteristics using nested circular plots. We measured diameter at breast height of woody species, over-story height, under-story height, density of shrub stems, ground cover, slope and aspect, and distances to edge and water. For each roost patch, three non-use plots were also measured following the same protocol. The tracking period for the tagged bats ranged from 1-26 days (mean 8.3 days). The bats were tracked to 108 roost trees. We found bats using 9 tree species for roost sites; fifty-six percent of roosts were located in white oaks (*Quercus alba*) while only seven percent used conifers. We are currently using an information-theoretic approach to test a priori hypotheses regarding factors affecting roost-site and roost-patch selection. A greater understanding of the habitat requirements of tree-roosting bats is necessary as development pressures continue to impact forested habitats. This information will assist in developing effective, data-driven conservation and management plans.

Hearing Bat Habitat: Anabat Surveys on the Fernow Experimental Forest
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We used Anabat II acoustical detectors to actively sample bat echolocation activity at 63 permanently located recording stations on the 1,800-ha Fernow Experimental Forest in the Allegheny Mountains of West Virginia. During the summers of 2001-2003 we detected *Myotis lucifugus, Myotis septentrionalis, Myotis sodalis, Eptesicus fuscus, Pipistrellus subflavus, Lasiurus borealis, Lasiurus cinereus,* and *Lasionycteris noctivagans*. Logistic regression analyses suggested that *Myotis septentrionalis* and *Myotis sodalis* activity was linked to small canopy gaps or closed forest conditions along small 2nd order streams whereas *Myotis lucifugus* and *Pipistrellus subflavus* activity was highest along larger 3rd to 4th order streams with discontinuous or open forest canopies. *Lasiurus borealis* and *Eptesicus fuscus* activity was greatest in medium-sized forest canopy gaps and linear openings along roads in upland conditions. *Lasiurus cinereus* activity was most noticeable within recently harvested forest stands, although its presence also was recorded above mature forest canopies and along forested riparian zones. Multivariate ordinations of bat echolocation activity indicated some foraging habitat segregation based on morphology, echolocation characteristics and or feeding strategy that minimized inter-specific competition. Although roost habitat management for species such as *Myotis sodalis* remains the conservation priority on the Fernow Experimental Forest, maintenance and management of foraging habitats that we identified also should be considered a critical task.

Summer Roosts of Male Northern Bats (*Myotis septentrionalis*)
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During the summer of 2003, we mist-netted and radio-tagged 11 male northern bats (*Myotis septentrionalis*) on the Fernow Experimental Forest in the Allegheny Mountains of West Virginia to investigate day-roost tree use and selection. We tracked these 11 individuals to 16 unique roosting sites. Thirteen roosts occurred in black locust (*Robinia pseudoacacia*), 5 in snags and 8 in live trees. The other 3 roosts we documented occurred in one sassafras (*Sassafras albidum*) snag and in 2 live sugar maple (*Acersaccharum*) stems. All live trees that we observed as roosts were medium to very large sawtimber-sized trees with copious amounts of exfoliating bark and numerous broken limbs and cavities. Snags used as day-roosts were less tall (P = 0.006) and less large (dbh; P = 0.006) than trees and snags in the surrounding stands, whereas live trees used as day-roosts were taller (P = 0.003) and larger (P = 0.003) than those in the surrounding stands. Similar to previous research with female northern bats in the Allegheny Mountains, we observed a strong selection (P = 0.004) for both live and snag black locust as day-roosts over other tree species that were available in surrounding stands. Forest management efforts that promote the regeneration and retention of black locust appear to benefit northern bats. Black locust snags that were overtopped and suppressed trees early in stand initiation can remain standing and available to bats for many years. These snags, in conjunction with the ability of some individual black locust to reach large canopy-dominant stature in the Allegheny Mountain provide suitable roosting substrate for northern bats in both young and mature forests in the region.

Silviculture and Habitat Objectives for Bats - Synthesis

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Silviculture has been defined as both an art and a science. The science of silviculture is found in the tools and techniques used to achieve specific conditions sought by a landowner, through the manipulation of the relative biotic influence of the many individuals and species of vegetation that occupy a given forest stand. In some cases that influence is drastic, involving the removal of most if not all trees on a site followed by reestablishment of a new age cohort of desired species. In other instances that influence is subtle, such as removing the biotic influence of a single tree to benefit a neighboring tree. The art of silviculture, then, is combining these individual practices into a silvicultural prescription through space and time so that the resulting forest stand contains the species composition, spacing, foliar distribution, product yields (both for timber and non-timber resources), and related ecological benefits that meet the objectives of the landowner. Increasingly, the public seeks a management philosophy that embraces multiple objectives for ownership. Thus, the challenge that foresters face in the future is both an artistic and a scientific one--to develop prescriptions that achieve these nontraditional objectives in creative ways, and to develop new and improved silvicultural practices, that enrich the collection of tools available to support those prescriptions. In this paper, we enumerate the silvicultural practices commonly used by foresters, we describe the ecological effects and forest physiognomic attributes that typically result from their application, and we speculate about the prescriptions that one might consider in the context of providing favorable ecological conditions for forest bats in managed forest stands.

Relationships between Forest Management and Bats

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Over the past decade, interest in the ecology of bats and the influence of forest management on bat populations has increased substantially. The increased interest has spurred a number of studies examining influences of forest management on bats. Many of the influences of forest management on bats are the results of indirect influences resulting from changes in forest structure, and these can be assessed at multiple spatial scales. Influences of timber harvest on availability and characteristics of roost sites is a key factor underlying responses of bats to forest management. Although there are no published empirical data documenting the relationships between abundance or density of bats and roost site availability in forested ecosystems, there is a substantial body of literature showing the use of large diameter trees and snags as roosts by bats. These studies suggest that conservation of these structures during timber harvest is a key element of conservation of bats in forests. At the scale of the forest stand, several studies have shown that bat activity is highest in riparian areas, old forests, and along habitat edges. Some species also have high levels of activity in open habitat and recent clearcuts. Densely stocked, young forest stands tend to have lowest activity levels. Managers directly influence suitability of sites for activity of bats through management decisions made at the stand scale. However, our understanding of the influences of forest management at the landscape scale is poorly developed; until ecologists are able to assess landscape-level consequences of stand-level decisions on abundance and demographics of bats, the ramifications of stand-level patterns will remain unclear. In addition to timber harvest, a number of other forest management practices can influence bats, including use of herbicides and insecticides, use of prescribed fire, fuels management, and construction and maintenance of forest roads. Relatively little information is available on the influences of these activities on bats. While our understanding of the roosting ecology of individual bats and activity patterns of bats is increasingly well developed, lack of rigorous assessments of the influences of management activities and structural attributes of forests on population abundance and demographics of bats obstructs a full understanding of influences of forest management on bats. However, our understanding of the influences of forest management activities on bats has increased substantially in the past decade, allowing some basic guidelines and principles to be used to guide management directions. We propose a conceptual model based on ecological niches of bats as based on roost site availability, clutter, availability of prey, and distribution of water. Although the model is not quantitative, it provides a heuristic device that may be useful to guide management decisions and generation of hypotheses to direct future research on the influences of forest management on bat populations.

Monitoring Bat Activities in Forests with Automatic Cameras

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Bats in forests are often photographed by automatic cameras with infrared sensors, which are set up for mammalian fauna inventory. We have applied this technique to monitor bat activities in forests by improving the device for the purpose and devising a new technique to lure bats to the front of the camera to increase their photographic rates. We set 10 devices along paths in the Nopporo Forest near Sapporo, Japan, on the trunk of trees standing on the side of the paths, at a height of ca. 220cm with a depression angle of ca. 45 ^{o} E toward the paths. The survey was conducted continuously from 16 July to 3 December in 2002, and from 8 May to 3 December (by schedule) in 2003. Two sets of 10 devices were used in turn every four weeks, and they were checked once a week to change films when necessary. Positive films of ISO 400 sensitivity were used. We have obtained 122 bat photos in 2002 and 187 bat photos in 2003 (as of 22 October). The preliminary analysis based on photographic rates suggests the following seasonal activity pattern. Their activity level arises in May, and then keeps rather constant until the middle of August. It then quickly increases almost three times as high as the previous level and keeps the level until the middle of September. It then begins to decrease and reaches the barely detectible level by the middle of October. The last bat photo was taken on 8 November in 2002. The result thus clearly reveals the bats seasonal activity patterns. The data can also be analyzed for their nightly activity patterns and their seasonal changes. Automatic photography is thus a useful technique to monitor bat activities in forests. It can also be applied to study the spatial differences in their activities: for example, the differences by height layers in forests. A significant merit of the technique is that it can monitor bat activities continuously through many nights with least labor and expense. The demerit is that it is difficult to identify species. However, some species of bat can be identified by measuring the size of photographed bats using their shadows on the photos.

How Forest Management Techniques Are Used to Alter Forest Stand Densities and Its Effects on the Roosting Ecology of the Northern Long-eared Bat (*Myotis septentrionalis*)

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Beginning 2001, the Buffalo Ranger District (BRD) in the Ozark National Forest (ONF), located in the Boston Mountains of Northwest Arkansas, began an alteration of a watershed located on the northwestern portion of this district. The basal area was reduced by 50%, via the use of wildlife stand improvements (WSI) and prescribed burning (PB) with the objective of restoring an Oak-Savanna habitat. This type of forest management was evaluated at two treatment and two reference sites. A WSI and PB were administered in the fall of 2001 and spring of 2002, respectively. Little or no management has occurred at the reference sites in relation to PB, WSI, and timber harvesting. Various aspects of the roosting ecology of female northern long-eared bats (*Myotis septentrionalis*) were evaluated in relation to the treatment being administered and changes in the relative forest stand density, which was measured in terms of its "basal area." Transmitters were placed on 33 individuals, yielding 259 roost localities. Our data show that this type of forest management did not negatively effect bats; moreover, bats continued or began to use areas where this forest management technique was administered, as well as select areas in the forest that were less structurally complex. Roost density and foraging distances were negatively correlated with forest stand densities, with bats selecting areas that were less structurally complex.

Winter Roosting Ecology of Pallid Bats (*Antrozous pallidus*) in a Central California Oak Woodland Forest

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Although pallid bats have been studied extensively during summer months, few studies provide information on the winter ecology of this species. In late October and early November of 2001, temperature-sensitive radio tags were attached to three males and two females. Males and females typically roosted together in a primary winter roost, an attic of a building located near a stream, but other nearby roosts were used intermittently. Bats exited their primary roost intermittently throughout the winter in temperatures as low as 4° C, although it was not determined if bats actually foraged during all forays (i.e., some bats may have only emerged to drink water). Day roosts were comprised of a attic of a building; trees, including a mature valley oak (*Quercus lobata*, diameter at breast height [dbh] = 52 cm), coast live oaks (*Quercus agrifolia*, dbh = 10 - 39 cm), California bay (*Umbellularia californica*, dbh 45 cm); and ground roosts (one under rags on the earthen bottom of a tool shed and one at ground level alongside an outhouse foundation). Winter roosts were located along the edges of a riparian oak woodland forest all within 100 m of a perennial stream. Females began roosting at a maternity roost (approximately 2 km from the winter roost and stream) in mid-March, while males continued to roost at and in the vicinity of the primary winter roost. Various males within the winter roost appeared reproductively active from late October to early January.

Bats and Forest Stands: An Empirical Synthesis Using Meta-Analysis
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In the early 1990's there was an increase in research effort on the interactions between North American insect eating bats and forests; specifically a number of papers on how bats used trees as roost structures and how stand characteristics affected the way that forests are used by bats were published. This research has continued and the field has matured to the extent that a level of synthesis is warranted. Two recent narrative reviews have summarized the field from different perspectives. In a review limited to the Pacific Northwest, Hayes (2003) focused on the advances in our understanding and describes what is currently known about the ecology of bats in coniferous forests. In a review with a continental focus, Miller et al. (2003) assessed the literature and suggested that there is a limited inferential ability of current studies because of problems associated with small sample sizes, the short term nature of studies, pseudo-replication, inferences beyond the scale of data collected, study design, limitations of bat detectors, and misuse of statistics. Narrative reviews are subjective and while acknowledging limitations in the studies examined, we are concerned that the latter review could provide incentive for leaving bats out of forest management considerations. Incorporating the available data into management prescriptions can be problematic, nevertheless harvesting continues and biologists are faced with the difficult task of making recommendations based on the best available data, which as Miller et al. (2003) point out, is not necessarily the same as the best possible data. The purpose of our study is to make the first objective and quantitative synthesis of the effects of stand characteristics on forest use by bats to clarify issues for biologists and forest mangers attempting to incorporate bats into current land use planning. Meta-analysis is a quantitative analysis of multiple studies that examines the full range of estimated effects for a given set of studies while incorporating sample size and disregarding significance. In another study examining roost-tree use by bats we show significant inferential ability of current studies when combined using a meta-analytic approach (Kalcounis-Rueppell et al. NASBR 2003). Here, using the same approach we examine how stand characteristics affect the way that bats use forests. Using approximately 25 Independent data sets from the literature, we examine the effect of harvesting, stand age, stand type, urbanization, and landscape features on the activity of bats using forests. As expected, our results show that significant inferential ability can be derived from combining current studies. There are species-specific effects of harvesting and overall relationships between bat activity and stand age and type.

Foraging Ecology of Forest Bats – A Synthesis
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Foraging behavior has long been a topic of serious investigation in mammal ecology, including experimental studies of bats, with emphases placed on testing optimal foraging theory and elucidating predator-prey dynamics. More recently, attention has begun to shift toward the study of bats in heavily, forested landscapes, with an interest in evaluating use of available habitats by bats and how these patterns relate to foraging and reproductive success. This shift has been made possible by advancements in technology, including radiotelemetry and acoustic monitoring devices, which have enabled researchers to collect data that otherwise was previously unattainable. Unfortunately, problems persist with these approaches limiting our ability to effectively interpret data on foraging behavior of forest bats. Forest bat species in North America are primarily insectivorous, so selection of habitats by bats is predicated on their ability to locate and capture a sufficient quantity and quality of insect prey. Although specialization in diet is evident in data sets of some species (i.e., moth strategists or beetle strategists), more often considerable variation exists in the variety of insect prey consumed, both among species and among sex and age classes within a species. Body design, including size and shape of wings, and echolocation call structures result in different foraging strategies among species, with some bats adapted to foraging in cluttered habitats while others are better suited to open habitats. Moreover, ontogenetic shifts in foraging patterns occur as juvenile bats mature into adults, and differences in foraging behavior are known to occur in reproductively active, adult females as they shift from pregnancy through lactation. In this synthesis, we review the existing data sets on North American forest bat species and evaluate these data in relation to current trends in management of forest landscapes.

Eastern Red Bat (*Lasiurus borealis*) Maternal Roost Selection in a Pine Dominated Forest of the Piedmont

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Although eastern red bats (*Lasiurus borealis*) are common bats in southeastern forests there have been few studies of maternity roost selection. The objective of this study was to determine red bat roost selection at the tree, microhabitat, and macro-habitat levels in a managed landscape. The study was conducted on the Clemson Experimental Forest, a 7,100 ha predominately pine regenerated forest. Eleven adult reproductive female red bats were radio-tracked for 107 days to 32 roost trees from May to August 2002 and 2003. We determined roost tree selection by comparing characteristics of used trees and non-used trees in the same stand, and by comparing use to availability at the stand and landscape scales. We determined microhabitat (within stand) selection using logistic regression to compare vegetation structures of the surrounding habitat between used and non-used trees. Macro-habitat (stand level) selection was established by comparing used to available stand classes. All roosts located were in live foliage of hardwood trees. Higher roost fidelity was found earlier in the maternity season than later. Roost trees had a larger dbh than non-used trees. Use/availability analysis indicated hickories (*Carya spp*.) were selected more than available at the stand and landscape scales. The micro-habitat surrounding roost trees had fewer trees >10.2 cm dbh, more woody stems 5-10cm dbh, a taller mid-story, and on north-northwest aspects. At the macro-habitat scale bats used mature hardwood dominated stands in proportion to availability and avoided pine-dominated stands. These results suggest that habitat management that favors the regeneration of hardwood dominated stands and retention of large hardwood trees (>30 cm dbh), particularly hickories, would be beneficial to reproductive female red bats in the Piedmont.

Microclimate Variation in Atmospheric Attenuation and Its Effect on Weather Station Placement

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Because bats are small, nocturnal and highly mobile, our understanding of their community ecology, habitat requirements and the effects of human induced habitat alterations on bat populations are poorly understood. Acoustic sampling has enabled researchers and land managers to sample bats in areas that cannot be easily sampled using capture methods. Measures of bat activity from acoustic sampling within and among habitat types can help provide information needed to make management decision for bat conservation. Measures of bat activity are possible using acoustic methods when atmospheric attenuation and other factors are taken into account to calculate the detection volume within the zone of reception. The variation in detection volume has been shown to double regularly, vary by 4 times often, and vary by 10 times with rapid changes in weather patterns from night to night at one location. These data originated from weather station information across the United States. This study defines the level of variation in atmospheric attenuation due to microclimate effects within a landscape applicable to bat research. The number and location of weather data collection sites will vary among studies based on their habitat type, geographic location, and spatial scale. The implications of these findings are discussed, and recommendations are made for collection of weather data.

Managing Special Landscape Features for Forest Bats, with Emphasis on Riparian Areas and Water Sources

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Landscape components important for forest bat conservation and management include natural features such as streams, ponds, and riparian areas, and artificial features such as bridges, culverts, cisterns, and constructed ponds. All forest bats require open water for drinking, and streams and ponds associated with riparian areas may represent the only available water in a region. Many species of forest bats also depend on riparian areas for feeding and roosting, and wooded streamside zones are important as movement corridors. Riparian and aquatic areas are well documented as bat foraging habitat, and wooded riparian areas often contain abundant snags and mature trees with loose bark; thus, providing potential roosting habitat for a variety of species. However, few North American studies have evaluated riparian quantity (e.g., width, extent, stream dimensions, associated ponds and wetlands) and quality (e.g., available roost trees, snag abundance, vegetative structure, water quality) with respect to life requisites for forest bats. Created water sources, wildlife ponds and road-rut ponds, are often utilized by bats where natural water supplies are absent or degraded. Such water sources are especially valuable in mountainous terrain, where roost sites on ridge-tops and upper-slopes are located more than a kilometer from uncluttered stream corridors. Three years of netting activities over streams (N=100), wildlife ponds (N=33), and road-ruts (N=99) on the Wayne National Forest, Ohio resulted in the capture success of 3.45, 7.21, and 3.00 bats/net night. Similar results are noted from Arkansas and eastern Kentucky. In the mountainous terrain of Kentucky, capture success of rare species, including *Myotis sodalis, M. leibii, Corynorhinus townsendii virginianus,* and *C. rafinesquii,* are greater over road-rut ponds located on upper-slopes and ridge-tops than over ponds and streams. Several studies have shown high use of artificial lakes and ponds by *M. grisescens* and *Pipistrellus subflavus* in the Southeast. However, bats are less likely to use created water sources in some regions of the U.S. (e.g., New England states) where there are abundant streams and wetlands with good water quality. Our paper describes characteristics of riparian and aquatic habitats determined to be important for forest bats. Methods for improving riparian areas as bat habitat are discussed, including stream restoration, buffer zone establishment, wetland development, managing for high densities of snags and cavity trees,

beaver pond management, fencing, and development of restrictions for road and trail construction. Recommendations are provided for evaluating and managing artificial features that are often associated with riparian areas, such as bridges, culverts, wells, and cisterns. Methods are described for constructing artificial impoundments and restoring wetlands, especially ridge-top wetlands, for the benefit of forest bats.

DecAID, The Decayed Wood Advisor for Managing Snags, Partially Dead Trees, and Down Wood for Biodiversity in Forests of Washington and Oregon

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Dead wood -- snags, down wood, and live decaying trees -- are habitat for many organisms that live in terrestrial ecosystems, and contribute to other aspects of ecosystem productivity and diversity. Maintaining an adequate level and mixture of these habitat elements can be a challenging task for any forest land manager. The DecAID Advisor is a web based planning tool intended to help advise and guide managers as they conserve and manage snags, partially dead trees, and down wood for biodiversity. DecAID is a synthesis of data and research results pertaining dead wood in forests of Oregon and Washington, integrating published scientific literature, research data, wildlife databases, forest inventory databases, and expert judgment and experience. The advisor also provides a summary of forest inventory data representing the range of "natural" (unharvested) and current conditions of snags and down wood in forests of all ownerships and disturbance histories. Interpretation of the wildlife and inventory data, as well as the relationship between the two sources of information is provided. Whereas the relationship of dead wood to wildlife habitat is a major component of DecAID, far more than just wildlife use of snags and down wood is addressed. DecAID also provides information on the array of key ecological functions and functional groups of wildlife that use dead wood. Interpretation and advice on the roles of insects and pathogens in the creation and dynamics of dead wood is provided in DecAID.

Bat Activity among Riparian Areas, Clearcuts, Pine Plantations, and Pine Savannahs at Three Heights in the Southeastern United States

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We compared bat activity levels in the South Carolina Coastal Plain among 5 vegetational community types: forested riparian areas, clearcuts, young pine plantations, mature pine plantations, and pine savannahs. We used time-expansion radio-microphones and integrated detectors to simultaneously monitor bat activity at 3 heights (2, 10, and 30 m) in each community. Variation in vegetative clutter among sampling heights and among community types allowed us to examine the differential effect of forest vegetation on the spatial activity patterns of clutter-adapted and open-adapted bat species. Monitoring activity at 2, 10 and 30 m allowed us to compare bat activity levels above and below the forest canopy. We detected calls of 5 species or species groups: eastern red/Seminole bats (*Lasiurus borealis/L. seminolus*) group, eastern pipistrelles (*Pipistrellus subflavus*), evening bats (*Nycticeius humeralis*), big brown bats

(*Eptesicus fuscus*), and hoary bats (*Lasiurus cinereus*). At 2 and 10 m, bat activity was concentrated in riparian areas whereas we detected relatively low levels of bat activity in upland forests at those heights. Bat activity was more evenly distributed across the landscape at 30 m. Bat activity levels above the forest canopy were almost 3 times greater than within or below the canopy. We detected significantly higher activity levels of 2 open-adapted species (hoary and big brown bats) above rather than within or below the forest canopy. However, activity levels of 2 clutter-adapted species (eastern red/Seminole bats and eastern pipistrelles) did not differ above, within, or below the forest canopy. Despite classification as a cluttered-adapted species, evening bat activity was higher above rather than within or below the forest canopy. We believe our results highlight the importance of riparian areas as foraging habitat for bats in pine-dominated landscapes in the southeastern United States. Additionally, our results show that significant bat activity occurs above the forest canopy. Although acoustical surveys conducted below forest canopies can provide useful information about species composition and relative activity levels of bats that forage in cluttered environments, such data may not accurately reflect relative activity of bats adapted to forage in more open conditions, and therefore may provide an inaccurate picture of bat community assemblage and foraging habitat use.

Evening Bat Day Roost Selection in Relation to Forest Management in Southwest Georgia
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The longleaf pine (*Pinus palustris*) ecosystem historically dominated the Coastal Plain of the Southeast. These forests provided excellent opportunities for cavity and bark roosting bats because large trees and snags were abundant throughout the landscape. Natural longleaf pine forests have been drastically reduced while intensively managed loblolly pine (*Pinus taeda*) plantations have increased in the Southeast. Intensively managed pine plantations have short rotation times (< 30 years) which may limit development of large trees and snags and, therefore, could limit opportunities for cavity and bark roosting bats. The objective of this study was to investigate the day roost selection of a cavity and bark roosting bat species in both intensively managed and natural pine forests landscapes. We chose the evening bat (*Nycticeius humeralis*) as a focal species because it commonly roosts in cavities or under exfoliating bark, it is frequently captured and is relatively abundant in pine forests of the Southeast, and it has been the focus of only a few studies in this region. We investigated day-roost selection of evening bats on two study sites in the Gulf Coastal Plain of Georgia. The Joseph W. Jones Ecological Research Center (Jones), Baker County, Georgia is a second growth mature longleaf pine reserve managed with a two year fire rotation. The Aultman Tract (Weyco), Worth County, Georgia is managed by Weyerhaeuser Company for loblolly pine sawtimber and pulpwood production with a 30-year, clearcut rotation. We identified roost trees using radiotelemetry and confirmed a sample of these with dusk emergence counts. We used logistic regression to create roost selection models for each study area by comparing tree, stand, and landscape variables between roost sites and random sites selected throughout each area. From May to August 2002 and 2003, we tracked 100 evening bats to 168 individual roost trees. On Jones, we tracked 32 females to 54 trees, 19 males to 34 trees, and 9 juveniles to 22 trees (n = 60 bats to 110 trees). On Weyco, we tracked 19 females to 28 trees, 15 males to 22 trees, and 6 juveniles to 8 trees (n = 39 bats to 58 trees). Bats used a variety of structures, but live conifers (*Pinus* sp. and *Taxodium* sp.) were the most common type of tree used on both study areas. Pine snags, hardwoods, and hardwood snags were also used as roost trees. The conservation implications of our roost selection models will be discussed in terms of forest management in the Southeast.

Selection of Diurnal Roosts by Red Bats (*Lasiurus borealis*) in an Intensively Managed Pine Forest in Mississippi

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Forest managers are increasingly expected to incorporate biodiversity objectives within forest landscapes devoted to timber production. However, reliable data on which to base management recommendations for bats within these systems is extremely limited. Although the red bat (*Lasiurus borealis*) is a widespread and common species in temperate forests of North America, little is know of their ecology within intensively managed pine (*Pinus* spp.) forests of the southeastern United States. Diurnal roost sites for red bats may be limiting on industrial pine forests due to a lack of large hardwoods within managed stands. Therefore, we investigated selection of day roosts by red bats at multiple spatial scales during June to September 2000 and May to August 2001 in an intensively managed pine landscape in east-central Mississippi, USA. We captured bats using 4-tier mist nets placed over water and attached 0.47 to 0.54 g radiotransmitters to captured red bats (n = 46). We located day roosts (n = 141 roosts of 27 bats) for the life of the transmitter. Red bats roosted in 16 species of hardwood trees (70% of day roosts) and loblolly pine (*Pinus taeda*; 30% of day roosts). In contrast to other studies in the southeastern United States, red bats in our study area routinely roosted within pine stands, in pine trees, and in mid-story hardwood trees. Within thinned pine stands, red bats tended to prefer roost trees with a denser sub-canopy and higher basal area as compared to random sites. Stand-level characteristics appeared more important than individual tree characteristics in choice of diurnal roosts. Except for adult males, logistic regression models of roost sites had high (∃79%) correct classification rates. Day roost site requirements of red bats may exhibit greater plasticity than previously thought. On our study area, intensive forest management appears compatible with diurnal roost needs of this species.

Relationships between Riparian Vegetation, Insects, and Bats in the Oregon Coast Range

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Riparian areas serve as the foci for bat foraging activity in forests of western Oregon, yet understanding of the food chains linking riparian vegetation, insects, and bats is extremely limited. We measured bat activity at 78 stream reaches and nocturnal flying insect activity at 24 stream reaches in the central Oregon Coast Range June-Sept 2002 and 2003. Bat activity was measured using Anabat echolocation detectors and insects were collected using black light and emergence traps. Preliminary analyses suggest that bat activity increases as the proportion of deciduous vegetation bordering stream reaches increases and that Lepidopteran abundance and diversity is greater in deciduous-dominated reaches than in coniferous-dominated reaches.

Importance of Night Roosts to the Ecology of Forest Bats

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Published material on night roosting behavior and habitat associations of forest bats in North America is limited because these ecological attributes are difficult to study. Additionally, surveys or incidental observations involving night roosting bats are rarely published and remain virtually unavailable as references. This chapter is a summary of night-roosting information we compiled from the published and gray literature and from queries of researchers and practitioners familiar with roost habits of North American bats. A range of night-roosting habits and structures is apparent in the information we have gathered. Although some forest-associated bat species seem to neglect night roosting, for others, it is a consistent component of their nightly time budget. In general, night roosting occurs year round during periods when bats are active. Nocturnal resting habits have been described for bats as ranging from short, solitary rests at random locations to relatively long respites in clusters that display fidelity to specific locations across multiple years. The surmised benefits associated with night roosting include social interactions, digestion, energy conservation, and refugia. Although a site used for night roosting also may be used as a day roost or hibernaculum, typically, night roosts represent a different temperature regime or environmental parameters so that they occur at alternative locations than those used for other types of roosting. Roost structures used for night roosting can vary between species and geographic regions and may depend in part on availability of certain types of roost structures. Sites used for night roosting are documented for both natural and non-natural structures although man-made sites account for the majority of documented night roosts. Across forest habitats in North America, concrete bridges are consistently documented as night-roost structures. Because certain styles of concrete bridges provide a pronounced thermal mass that absorbs and retains solar heat, they sustain temperatures through the night that can exceed ambient temperatures. Thus, bridges can provide thermal conditions conducive to night roosting. Despite the thermal benefits associated with concrete bridges for night roosting, the persistent documentation of their use as night roosts also may reflect a bias from focusing night-roost searches primarily on bridges. Documentation of less conspicuous night-roost structures, such as rock crevices and hollow trees, may require more sophisticated methods of survey such as radio-telemetry.

Bats and Bridges - A Users Guide

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This presentation provides a brief "user guide" for biologist and wildlife managers thinking of including bridges in their toolbox of techniques for monitoring bat populations. Data collected on bat use of bridges in the Pacific Northwest demonstrate the advantages and limitations of incorporating bridges as a component of any research or survey protocol designed to study bats. Data collected over a 10-year period on the Willamette and Deschutes National Forest indicates that nine species of bats have been captured at bridges with all but one of these species, the Townsend's big-eared bat (*Corynorhinus townsendii*), using bridges primarily for night roosting. Significant differences have been found in the species and gender of bats using bridges. Data collected in a systematic fashion over the course of several seasons indicate significant differences in species use of bridges on a nightly and seasonal basis. The relationship between ambient nighttime temperatures, bridge temperatures, and changes in night roosting patterns over the course of an individual evening and throughout a season provides an understanding of why these structures have become an important refuge for many forest dwelling bats. Finally, data indicate that bats captured and banded at bridges used as night roosts have some level of fidelity to selected bridges along a waterway. This provides us the opportunity to inventory local bat populations over time, further investigate night roost fidelity, and to study the social dynamics associated with night roosting.

The Ouachita Mountain Bat Roosting Study

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Little information exists on roost selection by forest-dwelling bats in the southeastern United States, an area dominated by a mix of second-growth forests and industrial timberlands with scarce old-growth forest. In addition, few studies have been conducted in landscapes where diverse forest types and silvicultural prescriptions are among the available habitats. Therefore, we began this large-scale study in 2000 to examine roost selection of forest-dwelling bats in the Ouachita Mountains. Our goal is to determine the effects of different silvicultural prescriptions on roost selection. To date, we have captured 656 bats of 8 species. We have instrumented 124 bats and located 264 roost sites. For eastern red bats (*Lasiurus borealis*), eastern pipistrelles (*Pipistrellus subflavus*), and northern myotis (*Myotis septentrionalis*), sufficient numbers of both sexes exist within the study area to eventually provide sample sizes large enough to compare males and females. Evening bat (*Nycticeius humeralis*) and Seminole bat (*L. seminolus*) captures have been almost exclusively male during the summer months. Few hoary (*L. cinereus*) and big brown bats (*Eptesicus fuscus*) have been located and it is likely our sample sizes will remain low. However, little information exists for these species in southern forests; thus, data from small sample sizes may still contribute to the knowledge base for these species. Analysis of data has not been completed but general trends are evident. Bats readily roost in forests that have been subjected to partial harvest (single-tree selection, group selection, and pine-grassland restoration). Bats also readily use mature second-growth pine-hardwood and old growth stands, but tend to avoid closed canopy pine plantations.

Artificial Roosting Structures for Bats in the Forested Piedmont and Mountainous Regions of South Carolina

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Nearly all of North America's 45 bat species rely on forests for their roosting or foraging needs. Bats are an integral part of forest ecosystems, and as primary predators of night-flying insects they save farmers and foresters billions of dollars annually. Bats hibernate and form maternity colonies in live and dead trees and use forests as foraging habitat, night roosts, and migratory corridors. In natural and managed forests roosting opportunities must be maintained in order to sustain healthy bat populations. Artificial roosting structures are a growing area of research and experimentation in bat conservation and management. Interest in bat habitat improvement and environmental education are among the factors that have intensified the interest in artificial roosting structures. This increased interest has led to frequent advances in bat house design and associated increases in bat use of artificial structures. However, the great majority of bat house experimentation has been conducted in non-forested settings. There is a need to determine if artificial roosting structures can be an effective habitat management tool in areas where timber production has been the emphasis, and natural roosts may be lacking. These structures could prove to be essential until natural habitat recovers. The objectives for this project were to determine whether artificial habitat could be a viable mitigation technique in a managed forest setting in South Carolina's forests. Biologists, wildlife technicians, researchers and volunteers with Bat Conservation International, Boy Scouts of America, Clemson University, the Francis Marion and Sumter National Forests, the National Wild Turkey Federation, International Paper Company, South Carolina Forestry Commission and MeadWestvaco Corporation partnered to construct, install and monitor artificial roosting structures in forest settings. In the spring and early summer of 2002 fourteen sets of artificial roosting structures were installed in forested sites throughout the piedmont and mountainous regions of South Carolina. Each set consists of three different structure designs: a five-chambered BCI nursery, a single-chambered Oregon wedge, and a 2-chambered rocket box. All three designs were constructed to have the same total roosting area, and placement on the landscape, box color, aspect, and other variables were standardized to the extent possible. Preliminary results show that after two summer seasons (mid-June to mid-August) of monitoring, almost 50% of the houses had received some use. Additional analysis will be conducted to determine factors effecting use.

A Data Logger Study to Determine Roost Habitat Conditions for Three Endangered Bat Species Inhabiting the Buffalo National River, Arkansas

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Three species of bats found at Buffalo National River are listed as endangered by the United States Fish and Wildlife Service. These species, the Indiana (*Myotis sodalis*), gray (*Myotis grisescens*), and Ozark big-eared (*Corynorhinus townsendii ingens*) bats, are afforded legal protection under the Endangered Species Act. The eastern small-footed bat (*Myotis leibii*), which is also found at Buffalo National River, is currently being reviewed for listing. National Park Service policies require the agency to conduct management programs to perpetuate the natural distribution and abundance of threatened, endangered, or candidate species. Bats are restricted to roosts with narrow temperature and humidity ranges. Information about these ranges is currently being acquired by Bat Conservation International and others. There is a general consensus among bat researchers that endangered bats are not tolerant of human disturbance. This is especially true during their hibernation and maternity periods. The goal of this project is to improve the recovery of these species by developing data sets to base future actions on. We have design a study to address the recovery of these three endangered bat species by collecting detailed data on the temperature and humidity ranges of their roosting sites using Bat Conservation International protocols. Specifically our study has the following two main objectives: determine the temperature and humidity regimes and dynamics of these endangered bat roosts in relation to seasonal changes, and detail these data by species using roosts, and document the number and timing of disturbances these roosts are receiving from humans entering the caves during the closure periods. Light sensing data loggers will quantify these data by recording light as being present or absent. Thus we will consider each observation of light present to be indicative of human disturbance at the roost. During the summer and fall of 2003, we installed light and temperature data loggers in 14 different caves. At each cave, we identified a primary and secondary roost site for data logger installation based on historical survey data. These data loggers will remain in place for at least two years. Periodic data downloading will be scheduled for periods when bats are not expected to be utilizing roosting locations in order to minimize chance of disturbance caused by researchers. Data downloading will begin in April of 2004. This poster details our study design.

Fall, Winter, and Spring Roosting Behavior of Eastern Red Bats and Evening Bats in Missouri

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Although generally considered to be migratory species, eastern red bats (*Lasiurus borealis*) and evening bats (*Nycticeius humeralis*) have been recorded wintering in south-central Missouri. For the purposes of this study, fall is September and October, winter is November, December, January, and February, and spring is March and April. Winter temperatures in this area regularly remain below freezing, and periodically reach temperatures below -20^0 C, with snow or ice cover being common. Regular and temperature sensitive transmitters, temperature recorders (iButtons), and video cameras are being used to monitor movement, roost and ambient temperatures, and for red bats, roost exiting behavior. Anabat II detectors are being used to supplement the activity data for all species present in the area. A total 15 red bats and 14 evening bats have been captured from 20 October through 21 December 2003. Seven reds and six evening bats were radio tagged and monitored in their fall and winter roosts. Early fall roosting behavior for both species is similar to that reported during the summer; tree hollows for evening bats and foliage in the canopy for red bats. However, during late fall, winter, and early spring, red bats have been found roosting in junipers, and oaks that have retained their dead leaves. These roosts provide shelter during rain and winds, but when temperatures fall below 8-10^0 C, they move into the leaf litter where they remain during inclement weather including snow and ice. Captive red bats that were kept under conditions similar to outside ambient temperatures also moved from hanging positions in their cages to positions under the leaf litter substrate as temperatures were lowered. Evening bats continue to use tree hollows throughout the winter, although these roosts are different from those used as summer maternity colonies and roost fidelity appears to be higher. These roosting conditions moderate the effects of rapid environmental change, but do not provide constant, above freezing temperatures that most other hibernating bats experience. Arousal and foraging is common for both species when evening ambient temperatures rise above 10^0 C, but red bats been recorded and captured at temperatures as low as 5^0 C.

***Myotis austroriparius* Use of Artificial Roosts in a Mixed Hardwood Forest**

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Roost surveys of woodland bats were conducted at St. Catherine Creek National Wildlife Refuge and vicinity, Adams County, Mississippi, from March 2002 through November 2003. In November 2002 we began to monitor a large population of *Myotis austroriparius* roosting in an abandoned cistern at Laurel Hill Plantation, a private holding adjacent to the refuge. The Plantation is predominantly mixed hardwoods with a prevalence of oaks (*Quercus* spp.), bitter-nut hickory (*Carya cordiformis*), yellow poplar (*Liriodendron tulipifera*), maples (*Acer* spp.), and black walnut (*Juglans nigra*). Bats were hand netted over the cistern monthly from November 2002 through November 2003. One-hundred and seventy-eight bats were captured, 61% of which were males and 39% females. *M. austroriparius* were also found roosting in 5 abandoned houses on the refuge. These houses were surveyed from March through December, 2002 and 2003. Thirteen individuals were hand netted in these roosts after pups were volant. Captured bats were weighed, sexed and measured. Roost characteristics for *M. austroriparius* were evaluated, and internal temperature, humidity and light intensity data were recorded. Roost dimensions, location of bats within the roost, and roosting substrate were also noted. A habitat characterization using the point-centered-quarter technique was conducted at each roost site and for the refuge as a whole. Standard mist netting was conducted at 24 sites on the refuge and plantation from April through October in 2002 and 2003. Sixteen *M. austroriparius* were captured at 5 sites, representing 22 % of all captures. Other bat species netted during the survey period included the evening bat (*Nycticeius humeralis*) (31%), Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) (29%), eastern red bat (*Lasiurus borealis*) (15%), and big brown bat (*Eptesicus fuscus*) (2%). Roost monitoring and mist net surveys will continue in 2004.

Habitat Correlates with Bat Presence, Abundance, and Activity in Louisiana Forests

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There has been little research on the effects of habitat disturbance and fragmentation on forest-dwelling bat species in southeastern forests, and it is not known whether research from other areas of North America is applicable to the often heavily managed, second growth forests of the southeast. Evaluation of wildlife-habitat relationships at only one spatial scale may impede the correct identification of biological trends because processes at other scales are ignored or averaged out. We examined habitat use by forest-dwelling bats at three spatial scales in forests of Louisiana. Sampling occurred for a total of 42 nights from April through August of 2003 in Kisatchie National Forest, State Wildlife Management Areas, and National Wildlife Refuges throughout Louisiana. Sampling locations were at least 3 km apart to minimize spatial autocorrelation of bat captures. Bat diversity, abundance, and activity levels were measured through the use of mist-nets and ultrasonic detectors. At the regional scale, habitat use was assessed between upland pine and bottomland hardwood forests that dominate large portions of the state. At the local scale (1-km radius plots centered on the sampling location), habitat-species associations were assessed for factors including relative fragmentation, amount of forest edge, proximity to water, and the proportional abundance of different habitat types, that could be obtained through analysis of aerial photography. At the proximate scale (460 m^2 plots encompassing the mist-nets), we evaluated the influence of tree diversity, tree density, tree size class, canopy height, canopy closure, net height, and stream condition. In addition to habitat features, we assessed the influence of temperature and lunar phase. A total of 186 bats belonging to eight species were captured. Common bats included *Nycticeius humeralis* (54.8%), *Lasiurus borealis* (15.0%), *Eptesicus fuscus* (9.1%), *L. seminolus* (7.5%), and *Myotis austroriparius* (5.4%). Preliminary analyses of results show that regional habitat type (P=0.0003), tree height (P=0.0007), and temperature (P=0.0142) are significantly associated with bat captures. Habitat type may be correlated to the presence of *E. fuscus*, *N. humeralis*, *L. borealis* and *L. seminolus*, whereas canopy height may be correlated to the presence of *N. humeralis* and *L. seminolus*. There was no evidence that lunar cycle influenced bat captures. With additional data acquisition and analysis, we will hopefully increase our understanding of habitat associations of forest-dwelling bat species, and provide insights that will aid efforts in bat conservation in southeastern forests.

Indiana Bat Habitat Attributes at Three Spatial Scales in Northern Alabama
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We captured and radio-tagged 9 (3 males, 6 females) active Indiana bats (*Myotis sodalis)* in the Bankhead National Forest (BNF) in 2002. All bats were tracked and located at two or more diurnal roost sites during the 3-week period following capture using radio telemetry and a GPS unit. These bats were located 67 times in 48 unique roost locations including a cave, a utility pole, and 46 trees. Micro-habitat characteristics of the 46 diurnal roost trees selected by bats and of the forest stands where roost trees were located were measured and compared with trees and stands at 46 random locations within unoccupied circles located in a representative portion of the forest using a series of t-tests. White oak, shagbark hickory, and loblolly pine composed 78% of all roost tree locations. More than half of these roost trees (56%) were alive. On average, roost trees were 62.7 feet high with a DBH of 25.7 inches. The mean height of bats in trees was 20.7 feet. The mean canopy cover at roost trees was 35.5%. Percent canopy cover at roost trees was the only habitat variable at this spatial scale to differ significantly from random trees (72.5%). Roost trees were most often found in loblolly pine stands (34%) or in the white oak-northern red oak-hickory stand type (26%). On average, these stands were 47 years old, but ranged from 0 to 108 years. Mean canopy cover in these stands was 65.8%, and the mean basal area was 64.2. The basal area of stands selected for roost tree location was the only habitat variable that differed significantly from random stands (92.8). We overlaid the roost location data over a GIS landscape image of the BNF. We used the minimum convex polygon method to represent each bat's home range. Landscape attributes were computed for each home range and for nine unoccupied polygons clustered around a random, but representative, point in the forest. These data were compared using a series of t-tests. Although violation of sampling independence (common capture point) negates a rigorous statistical comparison, we found that occupied polygons had a significantly greater ($p < 0.05$) proportion of hardwood acreage and old-growth acreage (100+ years old) and significantly less conifer acreage and forest type edge. The proportion of young forest (0-70 years) and mature forest (71-100 years) were not significantly different. Stream mile density was higher in occupied polygons, but not significantly ($p=0.20$) higher.

Evening Bat (*Nycticeius humeralis*) Use of Fork-topped Trees: A Potential Tool for Conserving Bat Roosting Habitat in Managed Pine Plantations of the Southeast
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During the last decade, the southeastern United States has become the top timber producer in the country. The primary objective of the forest product industry and many other private forest landowners in this region is timber production, while secondary or often a tertiary objective is wildlife management. Intensive forest management may limit snag formation, as well as cavities and dead branches prevalent in older trees, reducing available roosting habitat. From May to August 2002 and 2003 we used radio-telemetry to track evening bats to day roosts on a 14,000-ha tract managed for loblolly pine (*Pinus taeda*) production by Weyerhaeuser Company in southwestern Georgia. Thirteen bats, 10 of which were reproductive females or first year young, were tracked to 14 live loblolly pine trees with a fork-topped (also called bifurcated or codominantly branched). Emergence counts indicated that bats were using cavities that formed at the base of the fork. These fork-topped pines constituted the dominant roost structure used in upland pine habitat on the study site. Based on these findings, we investigated basic characteristics of fork-topped pine trees used as evening bat roosts. We then compared them to random fork-topped pine trees at multiple spatial scales using a logistic regression model. We suggest that fork-topped trees warrant further research as bat roost structures, particularly for reproductive females and first year young, on industrial timber land in the Southeast.

Tree Roosts of Rafinesque's Big-eared Bat, *Corynorhinus rafinesquii*, in Southern Mississippi

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Most ecological studies of *Corynorhinus rafinesquii* have been based on populations that primarily use caves or manmade structures (e.g., abandoned buildings) as roosts. However, this species also utilizes cavities of trees, which are thought to be the historical day-roosts of *C. rafinesquii* in the Gulf Coastal Plain. Previous studies suggest that tree cavities have a finite "lifespan" as suitable roosts for bats and are generally restricted in distribution. Because knowledge of tree use by *C. rafinesquii*, a species of concern throughout its range, was scanty, the goals of this study were to identify and describe tree roosts of *C. rafinesquii* in DeSoto National Forest, Mississippi. Using radiotelemetry to locate trees used by bats that we captured, we characterized roosts using both qualitative and quantitative variables specific to the individual tree and to its surrounding habitat. Of twelve tree roosts that we located, eight were *Nyssa* sp. and four were *Magnolia grandiflora.* Roost trees were relatively large (mean DBH = 78 cm), nine were alive, and most possessed "trunk hollows" rather than basal openings. Most trees were located ≤ 20 m from a stream; five trees were located directly beside the main channel. Five trees were used by multiple radiotagged individuals. Short-term roost fidelity (measured in days) was generally low, but several bats returned to the same tree multiple times during the session that they were monitored. Some trees were also re-used by *C. rafinesquii* over a number of years.

Ecological Role of Bats in Forest Ecosystems

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Most of America's 46 bat species rely on forests to varying degrees, either for food or shelter. In turn, forests nearly everywhere benefit from bats probably much more than is yet realized. The most abundant forest inhabitants consume vast quantities of insects nightly, including moths and beetles that are costly pests. Though long neglected in forest management planning, available evidence suggests that bats are essential to the health of forest ecosystems, fulfilling the same roles by night as birds by day. However, despite their vital roles, many of America's bats are in decline. Prior to the arrival of European settlers, millions of now endangered Indiana and gray bats lived in single caves, and their overall abundance likely rivaled that of the now extinct passenger pigeon. Yet today, fewer than 350,000 Indiana bats remain range-wide. In the 1870s great migratory flocks of eastern red bats were reported passing over for days at a time, a sight now vanished from American skies. A variety of factors have contributed to bat decline, including disturbance of hibernation and nursery caves, and a loss of large old cavity containing trees and snags. Forest bats often require loose, exfoliating bark and cavities in very tall trees that are dying or newly dead, and these are now scarce in many places, especially where forests have been converted to agriculture, lost to development, or converted to plantations. Bats also require alternative roosts in close proximity, in part because exfoliating bark and old snags are ephemeral in nature, and in part to find appropriate temperatures and avoid predators. When forests become monocultures, bats and other insectivorous animals face prey cycles that favor pests. Under such circumstances, fewer species of insects, sometimes the most prolific, can threaten forests in great abundance, while gaps between hatch cycles starve their natural insect predators. Management practices that ensure age diversity and retain snags and damaged trees, and that ensure plant diversity, can greatly benefit bat populations. In summary, both forests and bats are more secure when structural, floral, and faunal diversity are maintained. Helping bats is a wise investment in America's forests.

Challenges Associated with Inventory and Monitoring of Forest Bats

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Recent advances in knowledge of the ecology of forest bats have stimulated greater interest and action by those responsible for their management. Accordingly, questions regarding the population status of bats in forests and the number investigators charged with addressing such questions are on the rise. Nevertheless, little formal guidance is available on how to conduct reliable inventories or monitor populations of forest bats. Because of the dispersed manner in which they interact with their habitat, inventory and monitoring of forest bats is more difficult than for bats in other situations. However, the methods used to detect bats in the field and analyze the resulting data continue to advance, which presages improvements in the reliability and efficiency of forest bat monitoring. I will review existing and potential approaches to monitoring bat populations in forested ecosystems. The foundation for such work will be established through a review of some basic principles useful in the development of inventory and monitoring programs. The existing capabilities for monitoring bat populations will be reviewed and existing guidelines and monitoring programs will be highlighted. A critical review of the important techniques used to conduct bat inventories will be presented including: the strength and limitations of capture and acoustic surveys as well as roost searches. An assessment of the population parameters that can and cannot be reliably measured for forest bats using existing techniques will be presented and how this might be improved by applying analytical methods useful for other taxa. This will lead to a discussion of some specific recommendations for improving the effectiveness and efficiency of forest bat inventories at a spatial scales ranging from a single structure to the landscape. A look at the future of forest bat inventory and monitoring will serve as a conclusion including some potential products that could result.

RECENT LITERATURE

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News

Rodrigo Medellin was awarded **the 2004 Whitley Award for International Nature Conservation** given by the Friends of the Whitley Laing Foundation. Congratulations, Rodrigo, on receiving this prestigious award! For more details, go to: **http://www.whitleyaward.org**

Deaths Reported

Eugene Studier, University of Michigan - Flint
Frank Kallen, SUNY Buffalo

Future Meetings and Events

August (first week), 2004
A "Bat Blitz," co-sponsored by the Southeastern Bat Diversity Network, will be held in the Piedmont region of North Carolina. Sites to be surveyed will be in the Uwharrie National Forest, the Pee Dee National Wildlife Refuge, Morrow Mountain state Park, and Land Trust sites of Central North Carolina. For more information contact Mary Kay Clark at: **mkclark@aol.com**

August 7, 2004
The 3rd Great Lakes Bat Festival will be held at Cranbrook Institute of Science in Bloomfield Hills, MI. The Festival will include presentations about benefits of bats, bat houses, bat research, bat conservation, public health, and much more. Over a dozen different species of bats from around the Great Lakes and the world will be shown, as well as live animals from wetlands and rainforests. Programs will be presented concurrently from 10 am to 6 pm EST. Each lecture will be approximately 45 minutes. Live bat programs will be 20 minutes in length and run continuously from 10 am to 6 pm. From 6 to 8 pm, there will be a family BBQ, activities, and entertainment. A research experience will conclude the 12 hour event from 8 to 10 pm. Mist netting, bat detectors, light tagging, and radio tracking, will be performed and demonstrated at the Rouge River tributary that runs through Cranbrook grounds. For additional information visit the website at: **http://www.batconservation.org**

August 23 - 28, 2004
The 13th International Bat Research Conference will convene in Poland from 23-28 August 2004. More information about the conference is available at: **http://www.miiz.waw.pl/IBRC**

September 17-19, 2004
A Bat Conference organized by the Bat Conservation Trust of the United Kingdom, will take place between 17th and 19th September at the University of Reading. More information will be available on our website: **http://www.bats.org.uk** from May/June onwards.

October 27 - 30, 2004
The 34th Annual North American Symposium on Bat Research, will convene in Salt Lake City, Utah, October 27-30, 2004, hosted by Michael Herder. For additional information see our web-site at: **http://www.nasbr.org/** or contact Margaret Griffiths at **mgriff@illinoisalumni.org**

Future Meetings and Events (continued)

February 2005
Annual meetings for the Colloquium on the Conservation of Mammals in the Southeastern United States and the Southeastern Bat Diversity Network (SBDN) will be held in February 2005 at Paris Landing State Park in Tennessee (**http://www.state.tn.us/environment/parks/parks/ParisLanding**/). More information will be available on the SBDN website (**http://www.sebdn.org**)

July 31- August 5, 2005
The 9th International Mammalogical Congress will be held in Sapporo, Japan, and will include a symposium on "Ecology and Conservation of Bats in the Pacific Rim." For information about presenting at the bat symposium, please contact: **funakoshi@int.iuk.ac.jp** Additional information about the symposium and Congress is available at: **http://www.imc9,jp**

August 2005
The next European Bat Research Symposium will be held in Ireland in August 2005. More details will appear here as they become available.

October 19 - 22, 2005
The 35th Annual North American Symposium on Bat Research, will convene in Sacramento, CA, October 19-22, 2005. Winston Lancaster will host the Symposium. For additional information see our web-site at: **http://www.nasbr.org/** or contact Margaret Griffiths: **mgriff@illinoisalumni.org**

October 18-21, 2006
The 36th Annual North American Symposium on Bat Research, will convene in Wrightsville Beach, NC, October 18-21, 2006. Mary Kay Clark will host the Symposium. For additional information see our web-site at: **http://www.nasbr.org/** or contact Margaret Griffiths: **mgriff@illinoisalumni.org**

Announcement

Sandpiper Technology awards 2004 Equipment Grants

Thirteen university students and one nonprofit researcher received Sandpiper Technology Equipment Grants for the 2004 field season to conduct wildlife research. A range of video systems is available in the STI rental/grant fleet to explore burrows, cavity nests and underwater habitat as well as conduct time-lapse surveys. The program has been in place since 1997 and primarily serves students in the U.S. and Canada. The **STI equipment grants deadline is November 1** for the following Spring/Summer field season. Review the proposal requirements at **http://sandpipertech.com** .

PEEPER VIDEO GOOSENECK PROBES
Two gooseneck probe diameters are available-the Peeper (2.3 inch) and the Roo (1.0 inch).

Justin S. Barrett, M.S. candidate at Boise State University, "Demographic study of Southern Idaho ground squirrels and how a 'Peep-A-Roo' video probe can help."

Thomas Gorman, M.S. candidate at Minnesota State University, "Female behavior, neonate survival, and natal den site characteristics of river otter in southeast Minnesota."

Elizabeth Joyce, M.S. candidate at Utah State University, "The role of parental attendance and habitat heterogeneity in the reproductive success of swift fox (*Vulpes velox*) in southeastern Colorado."

Joel N. Strong, M.S. candidate at SUNY, Syracuse, "Seed dispersal and the ecological implications of harvesting red-footed and yellow-footed tortoises in Northwestern Brazil."

Guillaume Szor, M.S. candidate at the University of Quebec, "Den site selection by the arctic fox (*Alopex lagopus*) in the Canadian arctic."

AQUAPEEP VIDEO PROBE

This underwater color camera is mounted on a 16-foot pole and uses the head mounted video display.

Meagan Jones, Ph.D. candidate at the Antioch New England Graduate School, "Sexual selection and the role of female reproductive strategies in the mating system of the endangered humpback whale (*Megaptera novaeangliae*)."

SENTINEL SURVEILLANCE SYSTEMS

The time-lapse VCR records monochrome and color images from the auto-color camera.

William H. Keeley of the Raptor Research Center used the Sentinel System to study "The effects of human encroachment on the foraging ecology of the Ferruginous Hawk (*Buteo regalis*)."

Sonya LeClair, M.S. candidate at the University of Southern Florida, "Comparison of hatching failure in a wildland and suburban population of the Florida scrub-jay (*Aphelocoma coerulescens*)."

Rebecca McGuire, Ph.D. candidate at the University of Alaska, "Breeding biology and habitat use by King Eiders at Techekpuk Lake and Kuparuk Oilfield on the North Slope of Alaska."

Sunny K. Scobell, Ph.D. candidate at the University of Oklahoma, "Hormonal mediation of female aggression in the sex-role reversed Gulf pipefish during long-term competitive interactions."

Suann Yang, Ph.D. candidate at Washington State University, "Variation in plant-frugivore mutualism across a successional mosaic of Mount St. Helens and consequences for seed dispersal."

TREETOP PEEPERS

These pole-mounted video systems explore habitat as high as 50 feet.

Hilary A. Cooke, Ph.D. candidate at the University of Alberta, "Cavity nest webs and keystone excavators of Alberta's boreal forests."

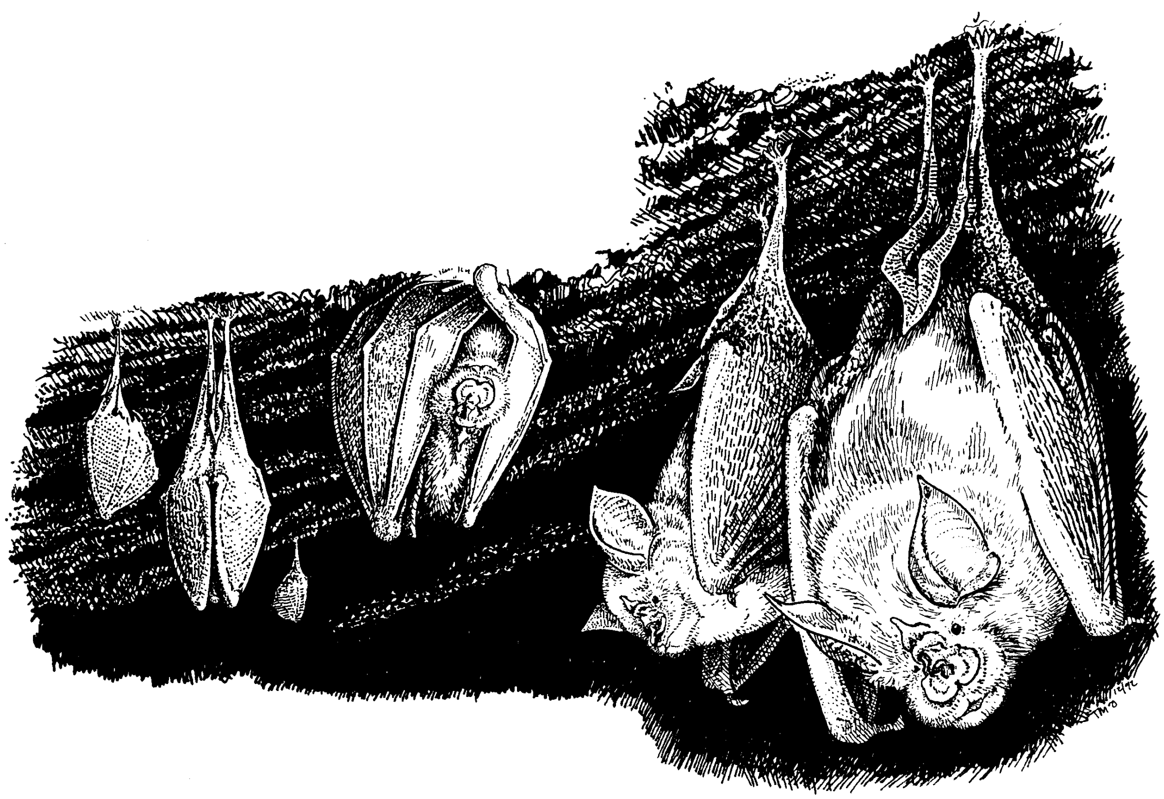
Henry Streby, Ph.D. candidate at Ohio University, "Thinning, burning and the response of nesting migrants in oak-hickory forests."

Maena C. Voigt, M.S. candidate at the University of Florida, "Post-release survival of Brazilian free-tail bats (*Tadarida brasiliensis*)."

Further details on equipment availability and proposal requirements for the Sandpiper Technologies Equipment Grant Program are available at: **http://sandpipertech.com**

Or contact Ann Christensen, Sandpiper Technologies, Inc., via email: **Ann@sandpipertech.com** or Tel. (209) 239-7560

BAT RESEARCH NEWS



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BAT RESEARCH NEWS

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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. In addition *Bat Research News* includes a recent literature section that cites nearly all bat-related publications in English worldwide; the 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.

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Front Cover Illustration

The cover illustration is courtesy of Tom McOwat, Llandysul, Wales. Thank you, Tom, for sharing the drawing.

An Unusual Day Roost of *Rhynchonycteris naso* (Emballonuridae)

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The variety of natural roosts used by bats is large, ranging from caves and dead trees to hollow logs, rock fissures, and foliage, and each type of roost represents a compromise among many factors, including thermal, behavioral, and ecological considerations (Kunz and Lumsden, 2004). There are, likewise, numerous records of bat roosts in human-made structures, many of which approximate the thermal, moisture, and tactile conditions afforded by natural sites. In this note, we report bats roosting beneath large fabric umbrellas in the beer garden of the public restaurant in the Horto Zoobotanico de Dois Irmaos (HZDI), a zoological and botanical garden within the city limits of Recife, the capital of the state of Pernambuco, in northeastern Brazil. Renovated in 1990, the park retains some areas of native forest and large bodies of water, both of which harbor indigenous wildlife.

At 1434 hours on 19 December 2003, during a visit to HZDI, we observed several small bats flying around the public restaurant. All flights ended under the canopies of several large (1.4 m in diameter) plastic-coated fabric umbrellas. Close examination showed that the bats were proboscis bats, *Rhynchonycteris naso*, which were identified by their facial appearance and presence of small tufts of white hair on the forearms (Emmons and Feer, 1997). Up to six individuals roosted together on the fabric of the umbrella's canopy, with heads facing its rim. When disturbed, the bats would fly either immediately to another umbrella or take a short flight around the restaurant before roosting in an umbrella. Only those umbrellas with fabric interiors were used, whereas those with plastic backings were shunned, probably due to the lack of purchase for the pedal claws of *R. naso*.

Conversations with the (determinedly anonymous) restaurant staff revealed that bats were a regular feature of the site and had been roosting there for many years. A short search revealed nearby a large samaumeira tree (*Ceiba pentandra*) that was the site of a second roost, with strings of up to 11 *R. naso* visible on the trunk, ca. 3 m above the ground. Both the tents and the tree were within 10 m of a large (ca. 1 ha), shallow pond that would have provided nocturnal feeding opportunities. Observations were discontinued at 1515 hours when staff insisted on closing and cleaning the restaurant.

To our knowledge, this is the first record of the regular use by bats of human-made umbrellas as roosting sites. A number of species of bat use umbrella-like tents made from leaves (Kunz and Lumsden, 2004), but *R. naso* is not among them. Artificial roots are generally chosen because they resemble some aspect of the natural situation for which they are substituting (Gelfand, 1997; Tuttle and Hensley, 1993). The choice of umbrellas as day roosts probably reflects the facility by which claws could be attached to the fabric and the sun-shielding offered by the cupola.

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Two Winter Roost Sites of Lasiurines in North-central Florida

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During the 1st week of January 2001, a Seminole bat (*Lasiurus seminolus*) was discovered roosting on the petiole of an introduced invasive plant, coral ardisia (*Ardisia crenata*), in a deciduous forest on the campus of the University of Florida, Gainesville, near a 20 ha lake. The temperature on the day the Seminole bat was observed ranged from 2.6 to 25.9°C, and the bat appeared sluggish and in short-term torpor because of the cold temperatures. The bat clung to a leaf ca. 0.9 m above the ground and its weight caused the branch to droop until it became supported by the branch below it. The branch holding the bat had three dark green leaves and the branch below held ca. 30 reddish fruits; about one-half the bat's body extended below the leaves and fruits. The roost site was located in mixed pine-hardwood forest that is a 5-acre natural area. The forest where the Seminole bat was roosting is dominated by such trees as sweetgum (*Liquidambar styraciflua*), loblolly pine (*Pinus taeda*), and laurel oak (*Quercus hemisphaerica*). A photo of this bat appeared on the cover of Wildland Weeds (Fall 2002, Vol. 5), a publication of the Florida Exotic Pest Plant Council.

In the same general area, but in a separate forest tract, a red bat (*L. borealis*) was observed roosting on a branch ca. 1.7 m above the ground in a laurel cherry (*Prunus carolinianus*) along a trail on 5-6 March 5-6 2004. Minimum and maximum temperatures on the days the red bat was observed were 18.1 and 26.0°C, respectively. The branch that the bat clung to had few leaves, but the bat was conspicuous. Laurel cherries retain their leaves through the winter, but because they are just starting to put out new leaves during early March, these plants have fewer leaves than at other times of the year. The roost site was in a mesic hardwood forest comprised of species such as sweetgum, red maple (*Acer rubrum*), and laurel oak.

Although roosting sites of Seminole and red bats in summer are becoming well documented (e.g., Hutchinson and Lacki, 2000; Menzel et al., 1998), comparatively little is known about their habits in winter. Most previously discovered roosts of Seminole bats in winter have been in clumps of epiphytic Spanish moss, *Tillandsia usneoides* (Constantine, 1958; Jennings, 1958). Red bats, in contrast, recently have been radio-tracked to resting sites in leaf litter during cold weather in Arkansas and Missouri (Boyles et al., 2003; Saugey et al., 1998). In addition, two red bats in Kentucky were observed roosting 1.5 m above the ground in an American beech (*Fagus grandifolia*) during a warm day in December 1990 (Koontz and Davis 1991). These reports and our observations suggest that lasiurines utilize leaf litter and low-lying vegetation under forest canopy as roost sites for short-term torpor during cold spells in forested sites in the southeastern Unites States. However, another red bat in Kentucky was discovered hibernating in a woodpecker hole in a snag when nighttime temperatures dropped below -3.0°C (Fassler, 1975), suggesting that red bats utilize an array of roost types in winter.

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Increasing Versatility of the Three-pole Netting Set

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Gardner et al. (1989) developed a widely used system to erect mist nets to a height of 9 m (30 ft). On each end of the net, their system used three telescoping poles, each 3-m long, and their system commonly is referred to as a "three-pole set." As part of this system, Gardner et al. (1989) also presented an option to erect systems using only two of the telescoping units to a height of 6 m (20 ft). However, that option rarely was used, because it required an alternate set of ropes and retained many of the difficulties and time-consuming aspects of the three-pole system, such as two guy lines for each pole, a "top line" that stretched between poles and above the net, and a minimum of two people for set up. A variety of two-pole sets have been developed since the article by Gardner et al. (1989), but they typically were incompatible with the three-pole set, requiring two nearly independent sets of equipment. However, with only minor modifications to the system of Gardner et al. (1989), we devised a quick, easy, and economical way to convert between two- and three-pole sets (terms follow Gardner et al., 1989).

The only permanent modification to the three-pole set of Gardner et al. (1989) is replacement of an eyebolt, which is located ca. 60 cm from the bottom of the assembled pole, with a hose clamp and a small "quick link." A quick link is similar to a locking carabiner and used to join chains or other objects; quick links are readily available at most hardware stores. The eyebolt originally was used for attachment of a "tension rope" that kept the "pulley rope" (a loop of rope to which the nets are attached and raised or lowered) taught. In our system, the eyebolt, which runs through the pole, must be replaced to allow a supporting rod to fit inside the bottom of the pole, as explained below. A three-pole, 9-m system is erected as before, except that the tension rope attaches to the quick link that replaced the eyebolt.

A two-pole, 6-m system (using the top and bottom poles of the 9-m system) now can be erected without guy ropes or the top line. To do so, a small-diameter supporting rod (concrete-reinforcement rod, small angle iron, or other metal rod), 1–1.3 m in length, must be pounded into the ground until only about one quarter of the rod remains above ground. A 6-m pole is positioned over the rod, and, if the substrate is soft, forced farther into the ground. The pole often will stand without further support, but if additional support is required, a single strand of nylon twine, tied between the pole and a nearby tree, is typically sufficient to provide support and keep tension on the net.

Like the three-pole set, pulley ropes must be attached before raising the poles. Pulley ropes (loops), however, must be shortened to fit the two-pole set. This is accomplished by tying a knot, a "figure eight on a bite" (illustrated in Padgett and Smith, 1987), 6 m below a trigger snap that is tied at the end of the loop (see figure 1 in Gardner et al., 1989). Dress the knot, and make it firm; however, do not tighten excessively. The position of the knot can be marked on ropes or easily determined as they are attached to the poles. The loop of the figure-eight knot must be long enough to thread through the eye of the trigger snap and over its head when unclipped from the other end of the pulley rope. The eye of the trigger snap is now attached to the figure-eight knot, and it is re-clipped to the other end of the pulley rope.

The pulley rope is once again a loop, but only 6 m when stretched taught instead of the initial 9 m. However, the 6 m of excess rope tied out of the pulley loop now dangles and may get tangled in other ropes, the net, or tree branches, so it must be braded (illustrated in Padgett and

Smith, 1987) to prevent tangling. Because the hose clamp and quick link may be used for additional adjustment of the length of the pulley rope, the eye of the bottom pulley is attached directly to the quick link, rather than using a tension rope. The tension rope is now nonfunctional but remains attached for use with the three-pole set, although adjustment with the hose clamp and quick link can be used to eliminate the need for a tension rope in both the two- and three-pole sets. Nets are hung on the two-pole (6-m) pulley ropes and raised and lowered, just as they are with the three-pole setup. To convert ropes back to a three-pole set, the braid pulls out, and the figure-eight knot is removed from the trigger snap and untied; in our experience, this knot never tightens sufficiently to make it difficult to remove.

Time to convert from a three-pole to a two-pole set or visa versa is only ca. 5 min, but time saved by use of a two-pole set (when appropriate) is at least 30 min during setup and 10–15 min during breakdown. In addition, the two-pole set can be erected and taken down by a single individual. Total cost for retrofitting a three-pole system is about $10 U.S., for two hose clamps, two quick links, and two pole rods, although purchase of a hand sledge to pound pole rods into the ground and pliers to help grasp the rods during removal is recommended.

Acknowledgment

I thank J. Gardner for his review of the manuscript.

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Utility Pole Used as a Roost by a Northern Myotis, *Myotis septentrionalis*

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Recently several reports indicated North American bats using utility poles as roosts. Included among these are a maternity colony of big brown bats (*Eptesicus fuscus*) roosting under a plastic guard (Winterhalter, 2004), a juvenile Indiana myotis (*Myotis sodalis*) roosting behind a metal clamp (Harvey, 2002), and a maternity colony of Indiana myotis roosting in a crack (W. D. Hendricks, pers. comm.). The purpose of this note is to report an additional case that we recorded during summer 2000, while conducting a study of artificial roosts used by northern myotis (*Myotis septentrionalis*) at the Indianapolis International Airport in Hendricks and Marion counties, Indiana. At this site, 3,204 artificial roosts of nine types were placed in woodlots to provide roosting habitat for the endangered Indiana myotis. Although these structures rarely were used by Indiana myotis, the artificial roosts were commonly occupied by northern myotis, (Sparks et al. 1998).

On 10 August 2000, we captured a pair of post-lactating northern myotis in one of the structures, located just west of the Indianapolis International Airport. Upon capture, we sexed, aged, and banded the bats. We then shaved the mid-scapular area of one animal and glued a 0.47-g radio-transmitter to its back. On 11 August, we searched throughout the 30-km^2 study area but failed to locate the bat. On 12 August, however, we tracked that signal to an electrical pole, owned by Indianapolis Power and Lighting and located along Indiana State Road 67, 7.6 km south of its initial roost. Subsequent counts at dusk, using both unaided vision and a thermal camera, indicated that the bat was alone in this roost from 12 to 15 August.

The area used as a roost was remarkably similar to that described by Winterhalter (2004). Power from the pole in Indiana was transferred to local houses via an underground cable, and a section of rubberized weather stripping protected the power line where it came down the pole and into the ground. Part of that weather stripping was damaged, and the bat was able to roost under this weather stripping.

With multiple recent reports of bats roosting in utility poles, one is drawn to the similarity of utility poles to typical roost trees. Most poles are made from moderate-sized trees, and programs aimed at reducing service interruptions regularly trim nearby limbs so that utility poles typically receive a substantial amount of solar radiation. Perhaps conservationists should seek partnerships with utility providers in an effort to provide bats with supplemental roosts by modifying utility poles.

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Abstracts of Papers Presented at the
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Abstracts are listed in alphabetical order by first author.

Implications of food hardness for diet in bats

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Neotropical bat communities are characterized by a broad species diversity, which can only be achieved and maintained through partitioning of the available resources. Here we investigate patterns of trophic resource utilization within a single neotropical savanna bat community. Moreover, we experimentally investigate the physical properties of food items (i.e. hardness), its variation with food size, and whether food hardness differs between items consumed by the bats in this community. Our results show that food hardness increases with the size of the food item, and that distinct differences exist in the amount of force needed to crush different food items (beetles vs. other insects vs. fruits). Using previously published data on bite forces from species in the same community we explore whether food hardness may play a role in shaping the diets of the bats in the community. The combined data on bite forces and food hardness indicate that food hardness can both directly and indirectly limit dietary diversity in bats. Our results also indicate that dietary specialization may potentially result in a decrease in trophic breadth for some species through its effect on bite performance.

Mating behaviour of crevice-dwelling antropophilous bats: *Pipistrellus kuhlii* (Vespertilionidae) do form leks

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We studied the mating behaviour of *Pipistrellus kuhlii* in a colony located in the campus of the University of the Basque Country (Northern Iberian Peninsula), where throughout the year bats occupy more than 100 crevices between the concrete blocks forming the parking roof. From July to December we checked all the used crevices twice per week. We tagged every bat found in the colony with double ring: numbered aluminum rings, and plastic rings with an individualized and unique color combination to allow visual identification. We ringed 54 males and 52 females. Observation of genitalia in males showed that mating season lasted since early September to late October. During this time all mating males selected for roosting neighboring crevices along the border of the parking. Each male occupied an area comprising several adjacent crevices, and remained there for several days or weeks, sharing the roost with one or two females each time. Males spent significantly more time than females in these areas. During the whole mating season 60% of males shared roost with two or more females (max = 6), whilst 69% of females shared roost only with a single male (max = 5). This behavior fits in better with a lek pattern rather than with a “resource defence polygyny”, previously described for *P. kuhlii* and other European pipistrelles. Authors consider this behaviour to be related to the high roost availability.

On new distribution records of bats from Iran

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Although reports on distribution and abundance of bats from Iran exist since mid nineteen century but these information are very few and have been accumulating very infrequently. Since 1980, when a comprehensive study carried out on the bats from Iran very few studies have been carried out. These are restricted to European bat biologists who visit this country from time to time. Additional information and new records of bats from Iran have been accumulating during past several years. The present paper summarized additional information of 36 distribution records of 10 species not previously known to bat biologist. These include 20 specimens of *Rhinopoma microphyllum* from 4 new localities, 16 specimens of *R. muscatellum* from 3 new localities, 2 specimens of *R. hardwickeii* from 1 new locality, 14 specimens of *Asellia tridens* from 4 new localities, 15 specimens of *Rhinolophus mehelyi* from 6 localities, 7 specimens of *R. hipposideros* from 2 new localities, 16 specimens of *Myotis blythii* from 6 localities, 12 specimens of *Miniopterus schreibersii* from 3 localities, 17 specimens of *Pipistrellus kuhlii* from 5 localities and 4 specimens of *Myotis capaccinii* from 2 localities.

Clustering behaviour of adult greater horseshoe bats, *Rhinolophus ferrumequinum*, in a nursery roost

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The clustering of adult greater horseshoe bats, *Rhinolophus ferrumequinum*, in a nursery roost in southwest Wales was recorded in April, May and September 2002 and 2003 using infrared illumination. Ultrasound social calls and low frequency social calls (Andrews and Andrews, 2003) were recorded simultaneously and temperatures in the roost were recorded automatically at fifteen minute intervals. In the roost bats hung from the inside surface of the roof, which was pitched. The roof apex ran approximately east and west and the roost floor area was 3m x 5m. There was a significant correlation between roof temperature and cluster size during the afternoon, especially in May, confirming that the primary function of clustering was body temperature control (Yalden and Morris, 1975: Hibernation. Pp. 75–77, *in* The lives of bats. David and Charles, London; Racey and Speakman, 1987: Symposium of the Zoological Society, London, 57: 107–125). Social calls were most frequently recorded when the clusters were forming or dispersing. The species is near the northern geographic limit of its distribution in south Wales and factors that affect the location and use of nursery roosts are discussed.

Comparison of ultrasound social calls made by adult greater horseshoe bats, *Rhinolophus ferrumequinum*, during the nocturnal return to a nursery roost before and after parturition

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Ultrasound social calls made by adult greater horseshoe, *R. ferrumequinum,* bats in a nursery roost in south west Wales, U.K., during the nocturnal returns to the roost in the pre-natal period in May 2001 were compared with the incidence of the same categories of calls made by the adults in the same colony returning to the roost to feed infant bats in July 2001. The interaction between maternal ultrasound social calls, at frequencies below those used for echolocation (83–84 kHz) by *R. ferrumequinum* (Andrews and Andrews, 2003), and infant ultrasound calls is discussed in relation to maternal echolocation and the isolation calls of *R. ferrumequinum nippon* reported by Matsumura (1979: Journal of Mammology, 60: 76–84). The difference in the incidence of pre-natal and post-natal ultrasound social calls made by adult *R. ferrumequinum* bats is discussed in relation the communal activity proposed by Rossiter *et al.* (2002: Behavioral Ecology and Sociobiology, 51: 510–518) and the need for cohesion in a large colony of animals in which the infant bats are left in baby clusters whilst the mothers engage in nocturnal foraging.

Ultrasound call made by infant greater horseshoe bats, *Rhinolophus ferrumequinum*, in a nursery roost and a comparison with the ultrasound social calls of adults

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Ultrasound calls of greater horseshoe bats (*Rhinolophus ferrumequinum*) of 1 to 21 days of age were recorded while the bats were being measured by McOwat (2001: Countryside Council for Wales Report, 3–4). The calls were recorded using a time expansion bat detector and cassette tape. The isolation calls of bats of 7 to 21 days of age were similar to those of infant *R. ferrumequinum nippon* reported by Matsamura (1979: Journal of Mammology, 60: 76–84). In the present study calls were classified by the frequency of the fundamental, the number and duration of the harmonics and the number of syllables used in a phrase and were compared with the categories of adult ultrasound social calls reported by Andrews and Andrews (2003: Acta Chiropterologica, 5: 221–234). Harmonics were recorded in all of the infant ultrasound calls (H2 – 100%, H3 – 61%, H4 – 35%, H6 – 0.5%). Harmonics in the range 83–84 kHz are in the frequency range of the acoustic fovea of the adult bats and would be optimal for the maternal location of an infant. Parallels between the social calls of the adults and the infant calls suggest that the adult ultrasound social calls have their origin in the calls of the infants although their purpose differs.

Winter activity of *Rhinolophus hipposideros* at the northern limit of its range in Great Britain

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The lesser horseshoe bat, *Rhinolophus hipposideros*, has a northwestern distribution in Europe that extends to the west coast of Ireland and the north coast of Wales. A large colony of the species that breeds in a cellar in north Wales has been monitored automatically for six years. About one hundred and eighty bats hibernate in the cellar. They are active throughout the winter and the number flying from the roost at dusk in the winter increases as the outside temperature rises above 5C, as does the mean time spent away from the roost. The apparent need for lesser horseshoe bats to feed during the winter explains why their distribution is limited to areas where the temperature on winter evenings may rise above 5C allowing the bats to hunt successfully.

Landscape-scale influences on spatial and genetic population structure in Pliocene relicts, Pilbara region, Western Australia

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Determining genetic population structure can be an integral part of determining the degree of genetic diversity within a population for the purposes of conservation and management. Undertaking this kind of investigation in an ancient landscape on rare, relictual bats that need to be considered in light of new iron ore and gold mining developments is truly multilayered and multifaceted. The bats *Macroderma gigas* and *Rhinonicteris aurantius* exist in the Pilbara region of north-western Australia as phylogenetic relicts from an Oligo-Miocene radiation and as geographical relicts from the effects of aridisation that began in the Pliocene. The Pilbara is represented by a complex of mostly Precambrian geologies that have eroded into a diverse array of landscape units that are mostly Tertiary in age. Not all of these provide suitable diurnal habitat for such cave-roosting bats that require relatively warm and humid microclimates. Extensive field surveys and the creation of models of spatial population structure undertaken previously have suggested that the Pilbara populations of these bats would be structured genetically. Patterns from mitochondrial DNA markers suggested some degree of genetic structure in Pilbara *R. aurantius*. New information on the genetic structure of Pilbara *M. gigas* suggests genetic substructuring, as promoted by an impediment known as the Fortescue Basin. The response of these two species to the structure of the

landscape was predicted to be different because of their different flight characteristics, diet and physiological constraints, however the influence of the landscape appears similar with the data so far obtained. These findings suggest that these bats need to be managed at finer scales than is currently being implemented.

Three new approaches for quickly and objectively classifying bat calls when using linear discriminant function analysis

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Three new approaches for providing quick and objective identifications of bat species from echolocation call variables are demonstrated. All rely on linear discriminant function analysis (DFA) at some stage of the process, but especially in the first instance to define distinct species clusters. The approaches utilise a bivariate scatterplot that can be produced from entering the variables measured from call sequences into the discriminant functions. All then determine whether a new point falls within the intra-specific call variation of each species, or within confidence regions based on that variation. Two of the approaches define this intra-specific call variation by a polygon, whereas the third uses confidence ellipses for prediction, which is similar to using Mahalanobis distance (commonly employed when using DFA to classify new cases). Each approach varies slightly in terms of its utility (i.e. ease of use or setup) and how conservatively they allocate identifications (i.e. the Type I error probability – not providing an identification when one should be given, although this is determined by the user in some methods). However, objectivity and the probability of a Type II error (i.e. providing identification when none should be given) is independent of method and related to the comprehensiveness and homogeneity of the reference dataset, and on decisions made regarding a “species complex”. It is anticipated that these approaches will be most useful for inventory surveys, and particularly so when used in conjunction with new automated software. The approaches need further testing on comprehensive datasets to illustrate in more detail their relative strengths and limitations.

Rediscovery of the flat-headed bat *Myotis planiceps* (Vespertilionidae)

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The flat-headed bat, *Myotis planiceps*, is a poorly studied species with one of the most restricted distributions of any bat that may be on the brink of extinction. Only three specimens had ever been recorded from the boreal forests in northeastern Mexico, and hence it had been listed by IUCN as critically endangered. However, neither past nor recent surveys had evaluated their conservation status. The type specimen was collected in 1952 in the state of Coahuila, and the most recent specimens in Nuevo León (1966) and Zacatecas (1970). The species is very distinct from other bats within the genus *Myotis*. Its small size and very distinctive flattened skull suggest adaptation to live in rock crevices, but very little is known about its biology and habitat requirements. Recently, we conducted an intensive survey focused on this species, and collected seven specimens, documenting the species for the first time in the past 34 years. Six specimens were captured near the type locality, and two others in new localities in Coahuila. All of the specimens were collected in boreal coniferous forests supporting previous observations that this species may be restricted to this type of habitat. Samples were taken for different assays, including different types of tissues, ectoparasites, feces, and internal organs. Echolocation calls were recorded and characterized, and used to determine that other bats flying in the surveyed area were also *M. planiceps*. Further studies are warranted to learn more about the basic biology, conservation needs, and ecology of this rare species.

Bat interactions with wind turbines

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During the last eight years bat collision mortality problems have been identified at many wind farms in Europe and the United States of America. Since then, several studies have been conducted to obtain data on species, number, and timing of the fatalities, as well as to examine influences of habitat, hunting behaviour and use of hunting sites. This presentation provides information on several aspects of the problem and a review of the present data from the USA and Europe. Nine European bat species and ten American species are reported to be killed, presumably from collisions with turbine blades. Most casualties are focused on species that fly high through open spaces while feeding or migrating (e.g., *Nyctalus noctula* and *Lasiurus cinereus*), but other species have also been found (e.g., *Plecotus austriacus* and *Myotis septentrionalis*). Mortality occurs primarily during the autumn migration period. Reasons for the bat collisions may be related to the high speed of the blade tips that either cannot be recognized or detected as obstacles by the bats. Studies have also found that *Eptesicus serotinus* in Europe seems to avoid hunting sites close to wind turbines, at least small wind turbines (30-m tubular towers with blade diameters of 30m). In contrast, *Pipistrellus pipistrellus* did not react negatively to the presence of turbines.

Differences in echolocation calls of *Pipistrellus pipistrellus* (Schreber 1774) and *Pipistrellus pygmaeus* (Leach 1825) in allo- and syntopic foraging areas

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The changes in echolocation behaviour and the structure of calls of *Pipistrellus pygmaeus* and *P. pipistrellus* were studied in south-eastern Moravia and northern Bohemia (Czech Republic) in 2002–2004, between April and the half June (before weaning) using a time expansion bat-detector. Some bats were also recorded in experimental laboratory conditions. We used multivariate analysis to distinguish influences of inter-individual and close conspecifics of each of both cryptic species on temporal and spectral pattern of call variables. The possibility that bats use their flexibility to avoid mutual disturbances of their echolocation calls was tested. This study was focused on signal adaptation and clarification of identification accuracy by bat detectors. Echolocation behaviour was influenced by the presence of conspecifics and individuals of second species. Individuals of *P. pygmaeus* emit signals with higher spectral variables during foraging in a group than during separate foraging. The research was supported by the grant of the Grant Agency of the Czech Republic No. 206/02/0961.

Bat communities of the riverine forests (Tisa and Latoritsa river basins, Ukraine)

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Riverine woodlands (mainly oak forest) in the lowland of Ukrainian part of Tisa and Latoritsa river basins are very important habitats for the occurrence and feeding of some bat species, especially for tree-dwelling ones. Bat detectors were used to record echolocation calls of bats on the line transects. As additional method the netting has been used. 20 bat species (almost 3/4 of Ukrainian bat fauna) are noted here. The most numerous bat species were *Nyctalus noctula* (up to 70% of censuses), *Myotis myotis* and *M. daubentonii. Myotis mystacinus*, *M. blythii*, *Barbastella barbastellus*, and *Pipistrellus nathusii* are uncommon or local species. *Myotis nattereri*, *M. emarginatus*, *M. bechsteinii, Nyctalus leisleri, Rhinolophus hipposideros* and *Plecotus austriacus* are rare and very rare here. Some species are known insufficiently: *Myotis dasycneme, Plecotus austriacus,* and *Pipistrellus pygmaeus*. Composition analysis was used to determine the micro-habitat preferences of the bats within study area. Eight bat species, which occur in this area, are included into the Red Data Book of Ukraine. Obtained data emphasis the necessity of protection of these riverine forests.

The National Bat Monitoring Programme: results of seven years of bat surveillance in the UK

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The National Bat Monitoring Programme (NBMP), run by the Bat Conservation Trust with core funding from the Joint Nature Conservation Committee, has been operating in the UK since 1996 and collecting population trend data since 1997. The programme carries out annual surveillance of bats across the UK, using four different methods – colony counts (six species at 815 colonies with a total of 5,014 counts to date), hibernation site counts (six species at 390 sites with over 2,000 site visits to date), bat detector field projects (five species at 343 field sites with a total of 4,305 survey visits to date). A network of volunteers collect the data, with over 1,500 volunteer contributing to the programme – 853 on colony projects, 617 on field projects and 83 on hibernation projects – with an estimated 7,672 days effort. We present the first seven years of results showing reliable population trend information for nine UK bat species, including *Pipistrellus pipistrellus, P. pygmaeus*, *Nyctalus noctula*, *Eptesicus serotinus*, *Myotis daubentonii*, *M. nattereri*, *Rhinolophus ferrumequinum*, *R. hipposideros*, and *Plecotus auritus*. Power analyses indicate that the surveys are able to detect IUCN Red Alert declines (50% over 25 years) for all nine species, and IUCN Amber Alert declines (25% over 25 years) for some species. The NBMP is also contributing to the Tracking Mammals Partnership, a new initiative involving over 20 organisations in the UK, with the aim of collecting population trend information for all UK resident mammal species, including bats.

Systematic status of North African populations of *Pipistrellus pipistrellus* complex (Vespertilionidae)

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The distribution of pipistrelles of the *Pipistrellus pipistrellus* complex (= *P. pipistrellus* s. l.) reaches only marginally the African continent, these bats are known from only a narrow strip of the Mediterranean zone in Maghreb and from NE Libya. We analysed museum specimens of African populations of *P. pipistrellus* s. l. using both morphologic and genetic techniques. The African representatives of *P. pipistrellus* complex comprise two morphologically, genetically and geographically very different sets. One distinct population inhabits the Mediterranean part of Cyrenaica, Libya. Belonging to the *P. pygmaeus* lineage, these bats are represented by great and rustier individuals with relatively and absolutely larger massive rostrum and canines. In morphologic traits, this population differs significantly from all Western Palaearctic populations of the *P. pipistrellus* complex. Within the *P. pygmaeus* lineage these bats are exclusive by their echolocation calls: the maximum energy of terminal frequencies is at about 45 kHz. In conclusion, we consider the Libyan pipistrelles to represent a separate species. Another distinct African pipistrelle population inhabits the Mediterranean parts of NW African countries, Morocco, Algeria and Tunisia. These are small and slightly darker individuals of the *P. pipistrellus* lineage with relatively shorter and narrower part of rostrum. Although both morphologic and genetic differences of this population from Eurasian *P. pipistrellus* s. str. were found, they are not on the specific level. However, the differences from European samples (incl. Spanish ones) show a rather step character and therefore potential subspecific level of NW African *P. pipistrellus* has to be taken into consideration.

Systematic status of African populations of long-eared bats (Vespertilionidae: *Plecotus*)

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Long-eared bats of the genus *Plecotus* are widespread over most of temperate Eurasia, marginally reaching the African continent and Macaronesia. Previously, all African populations were assigned to one species, *P. auritus*, and later to *P. austriacus*. We analysed museum specimens of African long-eared bat populations using both morphologic and genetic techniques. Based on morphological evidence we recognise four well-defined allopatric populations in northern Africa. They differ in fur colouration, skull morphology and bacular traits. The molecular data support a division of the African populations into at least three well-separated evolutionary lineages. With a combination these data we define three species of *Plecotus* occurring in Africa (incl. the Canary Islands) and describe a new subspecies. Small, very pale greyish-brown *Plecotus christii* inhabits desert and semi-deserts habitats of eastern Sahara (Libyan Desert, Nile Valley of Egypt and N Sudan). Smaller to medium-sized, dark brown *P. balensis* inhabits the Ethiopian Highlands above 2000 m a.s.l. of Ethiopia and Eritrea. This form represents the only known Afro-tropical species of the genus. Large, dark greyish *P. teneriffae teneriffae* occurs on the three western islands of the Canarian Archipelago. A medium-sized greyish-brown *P. teneriffae* ssp. was described from the Mediterranean region of Cyrenaica, north-eastern Libya. However, this new form is very probably consubspecific with the population that occurs in the Maghreb (Morocco, Algeria, Tunisia and Tripolitania). The systematic position of the population of Cape Verde Islands remains uncertain, previous Senegal records are considered dubious.

Systematic status of *Pipistrellus deserti* Thomas, 1902 (Vespertilionidae) within the *P. kuhlii* group

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The desert pipistrelle *Pipistrellus deserti* was described initially from the oasis of Murzuk in south-western Libya. It occurs in most arid parts of the Sahara, and is known from at least 15 sites in Morocco, Algeria, Libya, Egypt and Sudan. Records from sub-Saharan Africa (Ghana, Burkina, Nigeria, Uganda, Kenya, Somalia) were also attributed to this species, but this affiliation is uncertain. Although most authors consider *P. deserti* as a full species, others judge it as a subspecies, or even as a junior synonym of the Kuhl's pipistrelle, *Pipistrellus kuhlii*. We analysed Desert pipistrelles from Libya using both morphologic and genetic techniques, and compared them with *P. deserti* samples from other Saharan countries and with *P. kuhlii* from the Mediterranean and Middle East. *P. deserti* from Libya is morphologically similar to other populations from the deserts of North Africa. Besides from coloration, several meristic characters of *P. deserti* differ markedly from *P. kuhlii*. However, molecular reconstructions suggest that haplotypes of *P. deserti* from Libya are imbedded within the phylogenetic tree of *P. kuhlii*. Furthermore, these genetic data suggest that *P. kuhlii* from Libya and Greece are more closely related to *P. deserti* than to other *P. kuhlii* from the Middle East (Syria and Iran). Because the Middle Eastern *P. kuhlii* are also morphologically rather distinct from those of the Mediterranean, we suggest to split the Western Palaearctic *P. kuhlii* into three distinct subspecies. One would correspond to the nominative subspecies *P. k. kuhlii* (circum-Mediterranean), one to a desertic form *P. k. deserti* living in the Sahara and *P. k. lepidus* from the Middle East.

Development of placental barrier in the Indian thyropterid bat, *Tylonycetris pachypus*

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The present investigations of the placenta of thyropterid bat, *Tylonycteris pachypus*, at an electron microscopic level through the different developmental stages, has revealed that at the late neural groove stage no particular layering of the trophoblast has been observed. At the early stages of gestation there is a distinct maternal endothelium along with a compactly arranged cytotrophoblastic layers followed by the syncytiotrophoblast of varying thickness. The cytotrophoblastic layer at this stage of gestation bears vesiculated rough endoplasmic reticulum and well developed concentrically arranged Golgi complexes in fair population.However, the mid and term placenta of the same reveals the absence of the maternal endothelium. Instead the enclosed lacunae of the maternal blood space comes in direct contact with the cytoplasmic mass of the syncytiotrophoblast, i.e. ectoplasmic layer followed by the discontinuous intrasyncytial lamina in the syncytiotrophoblast. The syncytiotrophoblast bears a spongy appearance due to the presence of extensively modified vesiculated rough endoplasmic reticulum, while the cytotrophoblastic basal lamina displays extensively modified podocytic specialization, with some desmosomal connections while maintaining a distinct continuity across the limits of both the layers. Glycogen rosettes at the peripheral limits of the two trophoblastic layers are commonly seen. At places there is a considerable attenutation of both the layers into thin phalanges, bringing the maternal blood space and fetal capillary closer thereby reducing the thickness of the interhemal barrier. Absence of maternal endothelium and presence of both trophoblastic layers at term designates the definitive placenta is haemodichorial.

Baseline surveys and the developing of monitoring protocol for Lower Colorado River bat species

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European man has drastically changed the natural habitat of the Lower Colorado River (LCR) over the past 150 years. Dams, bank stabilization, and channelization have altered the flow and flood patterns, salinity and plant communities of the LCR. Over the past 50 years, declines have been observed in some bat species, notably the cave myotis, *Myotis velifer*, Arizona myotis, *Myotis occultus*, and Townsend's big-eared bat, *Corynorhinus townsendii*, that were at one time relatively abundant along the LCR. Causal factors may be the removal and replacement of native floodplain vegetation that supported the insect preybase; pesticide spraying in agricultural areas (conducted principally at night) that directly reduces the preybase and poisons the bats; and roost disturbance by the increased resident and recreational human population along the LCR. The goals of the current bat survey funded by the LCR Multi-species Conservation Program (MSCP) and Bureau of Reclamation are: to provide a better understanding of the past verses current bat assemblage along the LCR; to establish long-term monitoring protocol for bats utilizing current acoustic technology; to identify potential threats to bats; and to assist in the protection of critical roosts. Using a combination of acoustic recording techniques (principally Anabat), roost surveys and mist-netting, we detected 15 species along the LCR. The four National Wildlife Refuges support the greatest bat species diversity, and represent the areas least impacted by humans. Within the refuges, areas of cottonwood revegetation are visited by the most bat species.

Fixed foraging, flexible roosting – can we call *Myotis macropus* and ecological specialist?
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Like *Myotis daubentonii* in Europe, the large-footed myotis, *M. macropus*, from Australia is thought to be closely associated with permanent water. However, little is known of how strong this association is and whether foraging behaviour is influenced by the type of water-body present. To investigate this, five sites in south-eastern Australia with contrasting water-bodies were sampled: two coastal estuaries, an inland water-reservoir, and two sites on an inland freshwater river. Between October 2003 and March 2004 light-tags were attached to the ventral surface of 117 bats and their foraging behaviour observed for a median of 55 seconds. Eighty-percent of bats spent > 80% of the observed time foraging directly over water. The majority of time was spent 0–30 cm above the surface, with surface contacts every 21 ± 11 seconds (n = 79). Roosting behaviour was investigated at the inland water-reservoir where 21 individuals were radiotracked to 16 roosts; 13 in gum trees (including 2 maternity roosts), and three, including one maternity roost, in an aqueduct tunnel. All roosts were within 100 m of permanent water. Colony size was 1–29 individuals (median: 6, n = 23) in tree-roosts and 24 ± 4 (n = 4) in tunnel-roosts. Roosts in trees were predominantly in holes on the main trunk at an average height of 6.3 ± 2.9 m (n = 13). We conclude that *M. macropus* is an ecological specialist due to the species' clear reliance on the water-surface for foraging and the close proximity of roosts to permanent water.

Bats as indicators of environmental quality
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Daubenton's bat has a strong affinity for foraging at waterbodies and results of an investigation into the relationship between Daubenton's bat activity and waterway factors are presented. Between 1997 and 2001, 800 waterbodies were surveyed by volunteers for Daubenton's bat throughout the UK, as part of the UK's National Bat Monitoring Programme (NBMP). The Environment Agency (EA) collects waterbody data, including water quality and insect biodiversity measurements, as part of its General Quality Assessment Scheme (GQA). Additional factors, such as waterway width and flow categories (amongst many others), collected on the EA's River Habitat Survey (RHS) were also used in the analysis. A 'core' model (adjusted r^2 = 39.1%), that identified significant factors related to Daubenton's bat activity was constructed based on results from a regression analysis of factors in all 3 datasets using a non-automatic stepwise procedure. Significant factors included in the 'core'model included waterway width, flow rate, spatial location and insect biodiversity. The highly significant, positive relationship between Daubenton's bat activity and insect biodiversity, itself used by the Environment Agency as an indicator of water quality, demonstrates the value of bat monitoring data as an indicator of environmental quality. We recommend further studies linking bat population data with environmental variables, such as climate change and agricultural practices, that lead to bats being adopted as indicators of the success (or otherwise) of European environment policies on biodiversity.

Flight activity and habitat use of bats: what is correct interpretation of bat detector data?
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The aim of this study was to assess the seasonal and overnight changes in the flight activity and habitat use of forest dwelling bats in beech-oak forests by a detector monitoring. The transect method and automatic detector systems were used. The forest habitats visited from May until September 2003–2004 were divided to seven habitat types: deciduous forest, coniferous forest (fragments), open area (small meadow or clearcutting), forest edge (forest-meadow ecotone), stream, road and small water pools. Passing bats were divided based on call characteristics into two groups: non-*Myotis* group and *Myotis* group. Two peak of overnight activity were found, with maximum after sunset and before sunrise. Flight activity was high over open areas, forest edges and water pools. It was negligible inside the coniferous and deciduous forest. On the contrary, we suggest that forest interior is important foraging habitat for bats. The interpretation of results from bat detectors must be handled with caution, because of very different area of individual habitats. Higher activity need not mean the preference. We suggest that care should be taken when attempting to infer differential habitat use of habitats by bats using only acoustic techniques.

Genetic and echolocation call diversity in the endemic, cave-dwelling Formosan lesser horseshoe bat, *Rhinolophus monoceros*
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Intra-specific phylogenies can provide useful insights into how populations have been shaped by both historical and contemporary processes. The subtropical mountainous island of Taiwan is thought to have first separated from the Asian continent around 4 million years ago, though two or three land-bridges may have formed since then, coinciding with recent glaciations. The Formosan lesser horseshoe bat, *Rhinolophus monoceros*, is an endemic species found throughout the island, roosting mainly at low-altitude underground sites. To determine the colonization and demographic history of this species, we examined sequence variation in mitochondrial DNA control region in 203 bats sampled at 26 sites across Taiwan. Haplotype diversity was exceptionally high (98.56%), with a slight decrease in the south of the island (84.36%). By comparison, nucleotide diversity was low, with pairwise distance among the 106 haplotypes ranging steadily from 0.19% to 4.07%. Coalescent-based analysis indicated that divergence has occurred recently and that the population has experienced a demographic expansion in the recent past. Geographic variation in echolocation call frequencies also revealed differences between southern and other populations. We consider how these results might be used to identify populations for conservation management.

Utilization of foraging sites by *Myotis daubentonii* and *Pipistrellus nathusii*: effect of temperature, food availability and structural clutter
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Co-occurring bat species with similar diet but with different hunting tactics are expected to reveal different seasonal activity dynamics and forage in different habitats. *Myotis daubentonii* and *Pipistrellus nathusii* are morphologically similar, small-sized bats, foraging mostly in riparian habitats. They feed opportunistically on swarms of aquatic dipterans, mainly chironomids. However, they differ strongly in hunting tactics. *M. daubentonii* is a water surface forager, hunting mostly less than 0.5 m above water. *Pipistrellus nathusii* is an aerial hawker, foraging few meters above the water surface. We analysed changes in intensity of hunting activity of both species, recording their echolocation calls over the river and three ponds, located in close neighborhood. Each night insect abundance was monitored with sticky traps and air temperature was measured. Activity of *M. daubentonii* was not correlated with air temperature or with insect abundance. Insect number and biomass were significantly higher near the water surface than 4 meters above. Thus, hunting tactics of *M. daubentonii* gives him opportunity to utilize more abundant food source however it depends strongly on presence of smooth water surface. One of the studied ponds completely covers with flowers and stems of water buttercup *Batrachium fluitans* for some part of the season. *M. daubentonii* utilized this foraging site only in periods when water surface was not overgrown with vegetation. Probably, clutter echoes from plant cover strongly affects prey detection of this species, similarly as duckweed or water turbulences. Physical clutter associated with water plants seems not to affect activity of *P. nathusii*, significantly correlated only with air temperature and insect abundance. In March 2003 forestry workers built new pond in the study area. In the first year of its existence, it produced 2–4 times more insects than older water bodies. Thus, *P. nathusii* began utilize new foraging site much more intensively than the neighboring sites. Its activity significantly decreased over the older ponds, when compared to the year 2002, while insect abundance revealed no differences between seasons.

Improving the knowledge of the long-fingered bat, *Myotis capaccinii,* in the Comunidad Valenciana (Eastern Spain)

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The presence of *Myotis capaccinii* in the Comunidad Valenciana (Eastern Spain) is analyzed from data available. Eighteen roosts were studied, 13 of which were breeding sites. Data on distribution, abundance, phenology and conservation status of the species are shown. *Myotis capacinii* in the Comunidad Valenciana mainly occupied thermomediterranean areas, commonly below 400 m a.s.l. Nearly all roosts were not further than 10 km from permanent watercourses. The overall population of the Comunidad Valenciana has been estimated in ca. 5,000 individuals, which represents some 50% of the Spanish population. Births took place from late May on, and juveniles began to fly by mid June. We verified the syntopic presence of *M. capaccinii* and several cave-dwelling bats such as *Miniopterus schreibersii*, *Myotis myotis* and *M. blythii*. To a lesser extent, it also shared roosts with *Rhinolophus ferrumequinum*, *R. euryale*, *R. mehelyi*, *Myotis nattereri* and *M. emarginatus*. Statistical analysis of the forearm length showed significant differences between males and females (Mann-Whitney U = 3056.5; n_1 = 184; n_2 = 75; P<0,001). During the last years we have observed individuals of this species in 11 of 13 known breeding roosts. The other two colonies have disappeared due to inappropriate closing of the caves. *M. capaccinii* is scarcely represented in the Iberian Peninsula. This fact, together with roosts reduction and feeding habitat degradation, has lead to a new conservation status in the Spanish Threatened Species Catalogue, where the species appears now as "Threatened with Extinction".

Morpho-physiological responses of bats to changes in diet quality

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One of the most studied aspects of the physiological correlates of dietary diversification within bats is the relationship between rates of basal metabolism (BMR) and diet quality. The food-habit hypothesis postulate that the effect of diet on BMR in bats is causative in the sense that certain properties of the diet affect the way natural selection shaped patterns of energy acquisition and expenditure. However, at the proximate level, animals can trigger a series of responses to accommodate BMR in the face of a decrease in diet quality. Notwithstanding the purported importance of diet in shaping BMR in bats, these responses where never examined in detail for these mammals. Here we presented data on the temporal variation in the morpho-physiological responses of two species of bats, *Desmodus rotundus* and *Artibeus lituratus* to a decrease in their diet quality. By manipulating the digestibility and energy content of their diets, we aimed to analyze whether these species display an integrated processing responses, whereby the normal REE is not jeopardize, or if these bats simply down regulate the capacity of the central processing organs, whereby REE is down regulated at a lower level. If the food-habitats hypothesis holds at the proximate level, we predicted that vampire bats would not be able to cope with further decreases in the diet quality, while *Artibeus lituratus* would be able to maintain their normal BMR by triggering the integrated processing responses in face of a reduction in diet quality. Financial support: FAPESP (grant 00/09968-8).

Roost making as a cue for mate choice in d'Orbigny's round-eared bat, *Lophostoma silvicolum*
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A species' mating system is often closely connected with the amount of investment by mating partners into courtship and/or parental care. One form of such investment is the making of shelters, crucial for the reproduction and survival of many animals. In bats, the vast majority of species strongly depends on, but does not make, shelters. We investigate the bat *Lophostoma silvicolum*, which excavates active termite nests to use them as shelters. Due to the hardness of the nests, this behavior is probably costly in terms of time and energy. We found that the mating system of *L. silvicolum* is a resource-defense polygyny, where single males excavate the nests. However, only nest-males in good physical condition attract females, thereby achieving a high reproductive success (46%). The nests may serve as a cue for females, helping them to choose high-quality males. Reproducing females, in turn, may profit from the warm and stable temperatures in the termite nests. By allowing nest-holding males to sire their young, they indirectly justify the energy required for excavating the nests. Reproductive success may have selected on an external male phenotype, the excavated nests, and thus have contributed to the evolution of an otherwise rare behavior in bats.

Foraging areas of the notch-eared bat, *Myotis emarginatus,* in Upper Bavaria, Germany
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Ten *Myotis emarginatus* (9 females, one male) were radiotracked in summer 2003 near lake "Waginger See" (Upper Bavaria). The maximum distance between the nursery roosts and the hunting areas was 8.1 km. The females spend 85% of their foraging time in distances below 6 km and 66% in distances below 4 km from the colony roosts. The male foraged in a distance of up to 0.6 km from its roost. The bats foraged in forests (51 % of the time), cow-sheds (41%) and in orchards, riparian forest, settlements and fields (8%). They used riparian forests, hedges and tree lines as flight paths between roosts and foraging areas and avoided large open areas. The comparison between the forests at the foraging sites and the forest composition in the whole study area showed that *M. emarginatus* avoided spruce monocultures and preferred deciduous forests. In the study area the percentage of deciduous forests was 11%, spruce monocultures and mixed forests covered both 44.5%. At the foraging sites the percentage of deciduous forests (25%) was significantly higher and the percentage of spruce monocultures (16%) significantly lower. In mixed forests (59), the difference was not significant. 58 % of the foraging sites were located at creeks or small streams.

Evolutionary relationships among North American *Myotis* species (Vespertilionidae) and evidence of cryptic variation
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Bats in the genus *Myotis* are a diverse and successful group, occurring nearly worldwide and occupying a variety of ecological niches. Recent systematic research on *Myotis* suggests that the functional constraints of flight, echolocation, and particular foraging ecologies may result in morphological similarities that mask the underlying pattern of evolutionary relationships. Although the monophyly of American *Myotis* species is supported by recent research, relationships among these species are poorly understood. In addition, many North American species are difficult to distinguish reliably with morphological characters. This research presents the results of phylogenetic analyses of cytochrome b data for nearly all North America species, including other American and Old World *Myotis* species. Dense intra-specific sampling across the geographic ranges of putative species yields a level of resolution that permits testing for regional differentiation at the specific level. Results suggest that

ecomorphological convergence is widespread, resulting in confusion regarding the affinities of individual species, and that these morphological similarities masks profound genetic discontinuities within some recognized species.

Seasonal body mass changes of the five European horseshoe bats
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We studied body mass changes of five species of *Rhinolophus* during the summer season in the years 2001–2003. From April to October bats were caught in Bulgaria, Greece and Turkey, mostly when emerging from their roosts. We gathered 4,731 data sets comprising all five European species (*Rhinolophus blasii*, *R. euryale*, *R. ferrumequinum*, *R. hipposideros* and *R. mehelyi*). For analysis, data were divided in several subsets of the different species, sex-, age- and reproductive classes. All species showed a common pattern of body mass variation: Whereas nulliparous females and males had only little alterations of their body mass over summer season, reproducing females showed a much bigger variation. Highest body mass was reached during pregnancy, lowest during end of lactation. After the young were weaned, adult females increased their body mass very fast. In autumn, adult females reached a very high body mass at the beginning of hibernation, younger, nulliparous females were significantly lighter and young animals born in the same year started to hibernate with the lowest mean body mass.

Pattern of ganglioside expression in central nervous system of *Myotis* sp. bat
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Gangliosides are components of the plasma membrane. They consist of ceramide anchor and different number of sialic acid linked to inner or/and outer galactose sugar core chain (Gluc Gal GalNAc Gal). Gangliosides are ten times more abundant in CNS of higher vertebrates then in any of extraneural tissues. Out of almost 100 different types GM1, GD1a, GD1b and GT1b are major forms appearing in CNS. The exact physiological and neurobiological role is still unknown. However there is evidence that they participate in neurogenesis, brain development and maturation, synapse formation, memory, communication and adhesion of cells and information transduction. Physiologically they serve as NGF, EGF, insulin and interferon sensitivity regulators. Pathophysiologically they bind some biotoxins and participate in some cancerous processes. Furthermore there are recent evidences that they participate as CNS homeostatic factors in ectothermic and endothermic animals during hibernation allowing neural functions at low temperatures. Immunohistochemicaly, using monoclonal Ab against GM1, GD1a, GD1b and GT1b, we showed the distribution of gangliosides in CNS of adult *Myotis* sp. bat. The results are the major starting point for further possible research of hibernation changes, embryonic neurogenesis of pathways evolutionary specific to bats. Also the results could be used as aid and reference in biomedical research since they represent a good evolutionary comparison model to human ganglioside research data.

Contribution to bat fauna of the Biokovo Nature Park
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The aim of this study, conducted by the Biology student association – "BIUS" (Zagreb, Croatia), has been to collect data related to bat population in the Biokovo Nature Park. The echolocation sound frequencies of flying bats were detected using the bat detector. Bats were collected using mist-nets set next to the ponds, the source of drinking water for bats in summer. Upon the capture of the animal its gender was determined and basic morphological characteristics were measured, including body mass, length of the forearm, tragus and thumb claw. The animal was photographed and the species determined.

Between June 15 and 23, 2002, and April 26 and 31, 2003, total of 88 bats were collected, measured and determined at five locations on both sides of Biokovo mountain. Total of 11 bat species have been identified, seven of which are new species for this area: *Myotis blythii, M. emarginatus*, *M. mystacinus*, *M. nattereri*, *Miniopterus schreibersii*, *Plecotus* of the *austriacus* clade and *Plecotus* of the *auritus* clade. Four out of seven previously identified species were also found: *Rhinolophus ferrumequinum, Tadarida teniotis*, *Eptesicus serotinus*, and *Hypsugo savii*. Based on cumulative data from previous and current studies, total number of bat species identified in Biokovo Nature Park is 14. Members of the genus *Plecotus* have not been determined with certainty. Additional morphological and genetic studies, which would be based on a larger number of bats, are needed in order to further determine which bat species from the genus *Plecotus* live in the area of Biokovo Nature Park.

The evolution of echolocation in bats: a phylogenetic perspective based on nuclear intron sequences
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Existing family-level bat phylogenies based on morphology or different types of molecular data are contradictory. Within the Microchiroptera there are a wide variety of different types of echolocation, and the lack of a robust phylogenetic framework reduces confidence in any inferences that can be drawn about the evolution of echolocation strategies. Most phylogenies do not include many extant bat families, while others only used one to two species from each family to construct higher order relationships. We report on the utility of supermatrix analyses of four novel intron markers for resolving phylogenetic relationships amongst bat families. Seventeen of the 18 recognised bat families (represented by 55 taxa) as well as eight outgroup taxa have been included in the analysis. Preliminary analysis of a 1.5 kb intron supermatrix based on two of the intron markers confirms the paraphyly of Microchiroptera, with rhinolophoid microbats closely associated with the Megachiroptera. The evolution of echolocation within Chiroptera appears to be complex, with nasal echolocation evolving independently three times, once in the lineage leading to the Rhinolophoidea, once in the Nycteridae and once in the Phyllostomidae. Paraphyly of the microbats suggests that high-duty-cycle echolocation evolved independently from low-duty-cycle echolocation twice, once in the Rhinolophoidea and once in the genus *Pteronotus* (Mormoopidae). It also suggests that the possible split in the Yinpterochiroptera was based on one lineage evolving echolocation and the other greater visual acuity. The genus *Rousettus* in the latter lineage independently evolved echolocation probably in the context of its use of cave roosts. Further insights into the evolution of echolocation will be presented based on extensive phylogenetic analyses of a supermatrix containing all four novel intron markers.

Visual prey detection in vespertilionids
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Behavioural tests on optomotor responses establish visual acuity thresholds in five species of vespertilionid bats. Three species of *Myotis*, which are aerial-hawking bats, responded only to a stripe pattern equivalent to 5 degrees of arc. *Myotis daubentonii*, responded to 2.5-degree stripes, northern bats, *Eptesicus nilssonii*, showed reactions to 1 degree and the gleaning brown long-eared bats, *Plecotus auritus*, responded down to 0.5 degrees of arc. We also investigated the ability of brown long-eared bats and northern bats to make use of visual cues when searching for food. The long-eared bats were tested using petri dishes containing mealworms that were subjected to different levels of illumination. We presented four individuals with different sensory cues: visual cues, sonar cues and a combination of these. The bats preferred situations where both sonar cues and visual cues were available, however, visual information was more important than the sonar cues. The northern bats were studied in a field situation when searching for ghost swifts, *Hepialus humuli*, among clutter. We presented bats with white and dark

moths mounted on top of steel wires and found a significantly higher attack frequency on white ones. This suggests use of vision. When we reduced the size of the spread moths by cutting the wings, the preference for white individuals disappeared at 4 cm, indicating that this is the bats' visual acuity threshold. We hypothesize that northern bats, at least in the initial search phase, use visual cues as a complement to sonar to detect stationary ghost swifts.

Foraging northern bats, *Eptesicus nilssonii*, and their prey at complicated weather conditions

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During summer 1997, echolocating northern bats, *Eptesicus nilssonii*, were monitored with a bat detector in central Finland. One monitoring site was a streetlamp row consisting of 34 lamp-poles with Hg-bulbs. At each lamp post, passes and buzzes, weather and all potential prey insects were noted. Height of lamp-poles was 8 m and distance between them was about 40 m. Bats preferred mostly section of lamp-poles 10–16. It represents with its altitude lowest proportion of whole transect. Thin, foggy clouds were hanging above this section. Many feeding buzzes, frequent passes and absence of aggressive interactions (group of 3–4 northern bats) or associated low frequency calls were evidencing together the existence of aggregated and relatively rich food source. What kind of insects caused the concentration of activity like this? Usually lepidopterans and dipterans are quite easy to observe with powerful spotlight through thin fog or even light showers. But at this foggy section of streetlamp transect was just no insects and any bats active outside fog cloud itself. Are dipterans or aphids more vulnerable under influence of mercury vapour lamps like some lepidopterans? Could there be some associated thermoregulatory constrains for prey or predators to stay inside the chilly fog cloud (about 5°C colder as surrounding environment) above streetlamps? Another aspect of curious patch choice of bats and their prey is purely acoustical. What sense from bats' side is to concentrate their activity to the air mass with highest humidity, factor considered as major factor of atmospheric ecology affecting orientation and echolocation?

Northern, *Eptesicus nilssonii,* and Daubenton's, *Myotis daubentonii*, bats foraging at vertically crossing flyways: do they interfere each other?

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During chiropterological inventories louder calling bat species tend acoustically overwhelm more silent or whispering ones. Typical example at boreal latitudes is the northern bat, which manifests its own existence very noisy over all other species whenever present. In summer and fall 2000 I monitored with a detector equipped with DAT-recorder northern and Daubenton's bats foraging adjacent each other. Northern bat foraged above a row of streetlights on an old bridge and Daubenton's bats used the narrows below bridge (and northern bats) as their foraging path. Because the bridge was constructed over the narrows, the flyways of both bat species situated perpendicular and crossed vertically in relation to each other. Since the northern bat has large area of acoustical influence compared with all myotids, it was a good opportunity to document, if there exists interference or even spatiotemporal avoidance in association with feeding bouts between these two bat species. Experiences in the field evidenced rather wide indifference of these hunting bats against interspecific or intertaxonic sounds and environmental noise from various sources. Preliminary and rough investigations of about 12 hours of heterodyne and time-expanded digital audio tapes have not yet evidenced clear acoustical interference, dominance or avoiding patterns between northern and Daubenton's bats. More precise sound analysis like changes in the duty cycles, pulse repetition rates or spectral features of calls has to be done in the nearest future.

Skull morphological variability in three European and Mediterranean species *Myotis myotis, Myotis blythii,* and *Myotis punicus*: a geometric morphometrics approach

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Skulls of *Myotis myotis*, *M. blythii*, and *M. punicus* are difficult to separate with classical morphometrics tools. This work relied upon a geometric morphometrics approach, based on 59 homologous skull landmarks collected on 128 skulls. A Thin-Plate Spline Relative Warps analysis (equivalent to a Principal Component analysis of the Procrustes superimposed landmarks) clearly separated these three species of this complex and showed that *M. punicus* is not an intermediate form between *M. myotis* and *M. blythii* as often stated in litterature. Furthermore, *Myotis punicus* from Corsica and North Africa are clearly distinct in skull morphology.

Comparison of methods of estimating the abundance of bats in a winter roost in the Ore Mountains (Germany) and conclusions for a monitoring of bats in winter roosts

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Some methods of estimating the abundance of bats hibernating in a limestone mine in the Ore Mountains (Germany, Saxony) are compared. Therefore regular nettings (up to 6 times a week) were made in spring 2002 and 2003 and autumn 2002. furthermore the roost was visited during the winters 2001/2002 and 2002/2003. In addition a light barrier was installed in the only known entrance of the cave for getting the total number of wintering bats. During all capturing activities bats were ringed. That's why it was possible to calculate some estimates of the numbers of bats by using the capture-mark-recapture (CMR)-method. It was shown, that the majority of bats hibernates in hidden positions. The amount of bats that hibernates e.g. in crevices differs between species and between sexes. Because of the differences in the wintering strategy neither controls of winter roosts nor the CMR-method are not suitable for determination of the species composition, sex ratio and total number of bats wintering in this roost. Nettings in autumn are even not suitable for this aim because of differences in the swarming activity in this period. Furthermore it was proved that not all bats swarming in autumn at the winter roost hibernate in that cave. It was shown that a combination of nettings in spring with a light barrier was the best way of estimating the abundance and species composition of the winter colony.

Swarming behaviour and small scale genetic differentiation in *Plecotus auritus* populations

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We studied the swarming behaviour of brown long-eared bats, *Plecotus auritus*, in SW Poland from 2000 to 2003. Bats were caught and ringed during both spring and autumn swarming at a mine and radiotracked to their day roosts. Bats travelled from these roosts to the swarming site frequently, occasionally on consecutive nights, but returned to their roosts after a few hours. The 24 summer roosts studied were 0.5 to 30 km from the swarming site. Maximum distances were greater than expected for a bat with low wing loading and aspect ratio and small foraging home ranges. Males roosted closer to the swarming site. Genetic structure of swarming bats and those from summer colonies was investigated using 8 microsatellite markers. Low FST (0.013) and high gene diversities ($H_s = 0.756$) at both swarming sites and summer colonies were not statistically different and suggest high gene flow between these sites. Despite this, the sampled populations at summer colonies showed significant genetic differentiation from each other and from those at the swarming site. We suggest that swarming is important for gene flow and for maintaining genetic diversity, but random mating of all bats at the swarming site does not fully explain population structure. Bats from a given colony may travel to different swarming sites to mate, there may incomplete mixing at swarming sites, male mating success at swarming sites may be skewed or some copulation may take place in summer roosts.

Factors affecting the foraging activity of serotine bats, *Eptesicus serotinus*, in the agricultural landscape

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In order to study the foraging serotine bats, echolocation activity at 27 kHz was recorded with the heterodyne bat detectors at sites located within 3 km from a serotine maternity roost. The study area is dominated by arable fields and meadows and is bordered from the northeast by a large (over 300 m wide) river and from the southeast by predominantly coniferous woodlands of a national park. At each site eight all-night (sunset to sunrise) recording sessions were performed between mid-May and mid-September. Simultaneously, at the same sites three Malaise traps and one impact trap were placed and insect samples were taken to estimate the abundance of potential prey. Data on temperature, wind and cloudiness were also collected at the study sites during recording, although windy and/or rainy nights were avoided. Trapped insects were preserved, divided into orders and size classes and weighed. Each study site was described in respect to the habitat type, distance from the maternity roost and presence of linear landscape elements between the roost and the site. The poster analyses the influence of site location, habitat conditions and insect abundance on the echolocation activity and foraging of the serotines.

Juvenile pathologies in European insectivorous bats

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Every year newborn and juvenile bats are submitted to Wildlife Rehabilitation and Research Centers in Italy after being found in critical conditions. This work describes the most common injuries, parasites and nutritional disorders recorded in these patients during hand rearing and rehabilitation. Trauma to the wings membranes are frequent in young bats, probably due to their inexperience in the first attempts to fly. This kind of injuries could be very serious if the edge of the patagium is teared; the wing membrane in fact is so tin and tense because rich of elastic fibres that it is impossible sometimes to reconstruct the lines of the trauma. Suturing it is also often useless for the same reason. Fractures of the bones of the front and hind legs can also be observed. Depending of the severity of trauma, both conservative and surgical treatments are possible. The most difficult step during the immobilization of the fractured limbs is to prevent the membranes to colliquate as skin on skin is usually narrowed in the bandages. Antibiotic creams (Gentalyn Beta® Shering-Plough) are daily applied to bandages to keep the skin lubricated and disinfected. Corticosteroids applied locally are also useful to control inflammation and oedema. General therapy (fluids, antibiotics, vitamins: Metabolase® Fatro, Baytril® Bayer) is also usually performed as reported in the poster. Damages to the skin of the body can be treated with the techniques used in other mammals. Parasites are the ones usually found in adults. Nutritional disorders are common in hand-reared bats, also because there is still a lack of data about suitable diet requirements for captive bat patients. Skin and fur disorders of the skin and fur are related to vitamin C deficiency. Teeth loosing, malocclusion, delayed eruption of the teeth are usually related to mineral and vitamin deficiency. Skeleton developmental deformities as well as spontaneous fractures are due to a lack of calcium and vitamin C. Gastro-intestinal disorders are caused usually by the use of an improper milk replacer or weaning food (suitable milk replacers and weaning diets are reported in the poster). Clinical signs include anorexia, diarrhoea, lameness and death. Supporting therapy for nutritional disorders is reported in the poster.

Lack of function involves the increasing of variation in elements of the teeth system of some mouse-eared bats, *Myotis* (Vespertilionidae)

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The relation between odontometric variation and function in the teeth system of *M. myotis* (n = 16), *M. blythii* (n = 13), *M. mystacinus* s.l. (n = 13) and *M. daubentonii* (n = 5) was examined. The variation patterns of first lower molars that are well-developed and significant elements of the masticatory apparatus were compared with those of reduced and vestigial structures such as upper and lower small premolars and the third molar. The length, the width and the height of the teeth crown were taken (total number of traits is 50 per individual). The magnitude of variation (estimated by CV) correlates with functional value of teeth under study. The effects of allometry were tested for the variation patterns of under-developed structures. Probably, retardation in development and high magnitude of variation are the consequences of decrease in stabilizing selection pressure for functionally useless structures.

Evidence of sperm storage in *Myotis capaccinii* (Chiroptera: Vespertilionidae) in western Iran

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Several species of the genus family Vespertilionidae store spermatozoa for prolonged periods prior to ovulation, but the reproductive strategy used by *Myotis capaccinii* remains unknown. Reproductive cycle of this species has been determined using macroscopic and microscopic examinations on two captured bats in spring and one male and one female reared in a flight cage during winter. Microscopic slides prepared from one male collected in late July showed spermatids indicating that spermatogenesis develops in summer. Estimation of the volume of testes and epidydimes based on photographs taken on weekly intervals during late summer until late winter in one male *M. capaccinii* shows that the rate of epidydemis to testes volume increases by more than one order of magnitude from late summer until late winter. Microscopic slides prepared from this bat indicate that dicapacitated spermatozoa are packed in the seminiferous tubules in the epididymes in late winter.

Megachiropteran phylogeny: solving apparent conflict between molecular and morphological data

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Several studies in the last decade have investigated megachiropteran phylogeny using molecular techniques. These analyses refuted most traditional taxonomic groupings and recovered other groups with no obvious morphological support, suggesting overwhelming morphological homoplasy, especially in traits related to feeding habits like nectarivory. In order to address this conflict, we constructed a large morphological matrix including characters from diverse systems including osteology (skull, dentition, postcranium), integument (patagia, fur, rhinarium, pinnae), digestive tract (tongue, buccal mucose), and female reproductive tract. We combined our morphological data with the available sequences of the 12S rDNA, tDNA-valine, 16S rDNA, and cytochrome b, and the nuclear gene c-mos. Under direct optimization of molecular and morphological data, special efforts were directed at lowering all transformation costs through use of aggressive searches including ratchet, tree fusing, and iterative pass optimization. We found that although morphology alone recovers trees somewhat different from and partially incompatible with DNA-only trees, the combination of the two sources of evidence yielded a well-resolved, well-supported phylogeny of the Megachiroptera that easily reconciled the morphological and molecular signals. Successively recovered groups were nyctimenines, cynopterines, dobsonines, pteropines, a reduced macroglossine clade, rousettines, and myonycterines + epomophorines, with *Megaloglossus* and *Eonycteris* within myonycterines and rousettines, respectively. The robustness of the approach becomes more evident when considering the average 3-fold increase in support of suprageneric groups common to those recovered by the molecular partition alone. In conclusion, the combined analysis reveals low conflict, previously underestimated morphological support for molecular groups, and hidden molecular support for taxonomic groups.

Cranial osteology of *Pteropus*

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As part of an ongoing program of research on chiropteran morphology, a complete osteological description of the skull of *Pteropus* was undertaken with the aim of providing a reference on morphological description and terminology to bat researchers in particular and mammalian morphologists in general. Because bone fusion precludes detailed study of the limits and relationships of cranial bones in adult bats, subadults were examined for the primary description. The focus of study were specimens of *Pteropus lylei* housed at the Carnegie Museum of Natural History and the American Museum of Natural History. Additional observations were made on specimens of *P. livingstonii* and *P. capistratus*. The work has six main sections: description of the skull as a whole in the model species, description of the external surfaces of each bone, description of the internal surfaces of the skull, dentition, foramina contents and homology, and development. Foramina contents, muscle attachments, and problematic bone relationships were identified (and their homology issues addressed) in two sectioned fetuses (*Pteropus giganteus* and *Pteropus* sp.). Terminology was standardized whenever possible according to the Nomina Anatomica Veterinaria, and synonymy of a wide set of historically used terms was made explicit. Particular topics, such as the pattern of bone overlap, the pattern of occlusion and tooth wear, and ontogenetic transformations in general, were given special attention. Extensive comparisons with other megachiropterans were made to place the cranial osteology of *Pteropus* into a broader perspective.

A study of bats (Chiroptera) from an urban area of Oslo

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During the summer of 1993 a project was carried to survey bats in an urban townships of Oslo in Norway. These animals live in close relation to human activity thus making human activity influential to bat distribution and survival. Using bats as an indicator might therefore give information on natural health condition in this urban area. The project was carried out as an assignment for the Center for Development and the Environment at the University of Oslo. This project' objectives were to find the species diversity and distribution of foraging individuals in an urban landscape. From this an assessment would be made of the landscapes importance for the respective species. From the total amount of surveyed individuals, *Eptesicus nilssonii* constituted for over 90 percent. *Vespertilio murinus* had at Østensjøvannet a small foraging population of 10 to 20 individuals. The remaining species were recorded in very low numbers, and only in connection to the lake Østensjøvannet or its immediate surroundings. All species, except *Nyctalus noctula*, are however found regularly in the region. *Plecotus auritus* was an expected species, but no records were made. In general the density of foraging *E. nilssonii* increased as the urban categories changed from U1 (industrial areas) towards U4 (residential areas). This is believed to be caused by the increase of vegetation and macro habitats. Still, the lake Østensjøvannet seems to stand out concerning the density of foraging bats. Along a 4 km path surrounding the lake a total of 414 to 616 *E. nilssonii* were counted during a single trip. The number of bats found around Østensjøvannet constitute for more than 60 % of all the bats found within the entire investigated area of Oslo! This does strongly indicate the importance of wetlands for bat diversity and density also within urban areas. An interesting observation was that agricultural habitats had lower density of bats than industrial habitats.

Mapping the distribution of bats (Chiroptera) in Norway

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In 1992 Nordre Øyeren Biological Station (NØBI) initiated a national atlas on bats. This was encouraged by the poor information that then existed on the distribution of bats in Norway, and by the responsibility that was given (NØBI) to collect data for the European mammal atlas (EMMA), and the lack of interests amongst other organizations. Mapping the distribution of bats in Norway is a national project, which was initiated by (NØBI), and later taken over by the Nordic Chiroptera Information Center (NIFF). The objectives of the bat atlas was to a) map the distribution of bats in Norway; b) carry out a project that all members of NIFF can participate in; c) gather data as a contribution to the EMMA project that was organized by Societas Europaea Mammalogica. The final objective was to produce national maps divided into 10 x 10 km^2 grids using the UTM-system. Each square is filled with a symbol giving information about reproduction, mating calls, large numbers, regular, accidental records. Symbols were also given for squares checked without any bats recorded. Also the extent of fieldwork per square was indicated with own symbols.

Ecology of cave roosting bats in the Yorkshire Dales National Park, UK

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The Yorkshire Dales National Park contains the largest area of cave-forming karst landscape in the UK. Five of the ten bat species resident in Yorkshire are found hibernating in these caves, but they are crevice-dwellers and visual winter surveys most certainly underestimate their abundance. This has meant that the caves have been a low conservation priority in the past – at least with regards to bats. We are re-assessing the importance of the Dales' caves to bats, especially as swarming and hibernation sites, by capture at caves in late summer and autumn and by automatic logging of echolocation calls in autumn and winter. Swarming activity is being related to cave morphology and local landscape features in an attempt to determine what makes a good swarming cave. Initial results show a correlation with the number/size of chambers within the cave, but not cave length or entrance size. Sites with the most activity are all at high altitude, though they are often the most remote in relation to lowland summer habitat. This may reflect the fact that many lowland underground systems are flood prone. Similar methods are being used to see if swarming caves are also good hibernacula, or whether other factors govern their use. The summer bat populations of the Dales occupy a series of narrow valleys that are separated by areas of high-altitude moorland. Local geography and the distribution of caves in this landscape probably influence the movements of bats between summer roosts, swarming sites and hibernacula. The extent and pattern of this temporal dispersal will determine the genetic structure of bat populations across the park and genetic analysis using microsatellite markers is underway to study this.

Effects of habitat transformation on bat diversity in the Lagos de Montebello region, Chiapas, Mexico

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The effects of human disturbance on the diversity and structure of bat communities were assessed in five habitat types of the Lagos de Montebello region in Chiapas, Mexico. The comparisons were based on samplings in pine-oak-sweetgum forest, montane cloud forest, and pine forest (habitats relatively well preserved), as well as in coffee plantations, cornfields, and pasturelands (moderately and highly disturbed habitats). Each habitat was defined through six structural variables. Mist nets at the understory level were used for capturing bats during 25,290 net meters-hours, recording the presence and relative abundance of 21 species. There was no significant difference in bat diversity (expressed through seven ecological parameters) among the five habitat types. Similarly, there was no positive association between bat diversity and any of the six variables of habitat structure. Beta diversity was low and similarity was high among the five bat assemblages compared. This suggests that: a) bat diversity in the study area is not determined by the habitat type, and b) because of their vagility, bats can move indistinctively through different environments to forage. Bat diversity is probably more related to landscape elements than to the local habitat structure in the study area. Generalist frugivore, nectarivore, and hematophagous bats are dominant species in the Montebello region, which may be an evidence of its highly disturbed condition. Therefore, it is important to emphasize on the need for conservation and restoration programs of forested habitats for maintaining local bat diversity.

The conservation biology of the southern bent-wing bat, *Miniopterus schreibersii bassanii*

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Miniopterus schreibersii, suborder Microchiroptera, family Vespertilionidae, is a widespread insectivorous obligate cave-dwelling bat found across parts of Europe, Africa, the Middle East, Asia and Australia. In Australia three subspecies are recognised. *Miniopterus schreibersii orianae* is found in the north and north west of the Australian continent. *Miniopterus schreibersii oceanensis* occurs along a coastal band on the east coast from Cape York in Queensland to Castlemaine in Victoria, with six major maternity colonies. The Southern bent-wing bat, *Miniopterus schreibersii bassanii*, is found in south-eastern South Australia and western Victoria, and has just two maternity colonies, Bat Cave and Starlight Cave. The peak adult bat population at Bat Cave is currently 27,900–30,800, down from 70,000–140,000 in 1964, raising concerns about the viability of this population. The Starlight Cave population appears to be stable at around 14,000–15,570. We used infra-red video recording of evening fly outs to perform economical, non-intrusive and repeatable population monitoring at *M. s. bassanii* maternity caves. This method proved less intrusive and less labour-intensive then mark-recapture methods. Night time aerial radio tracking of foraging *M. s. bassanii* revealed the bats were foraging over native scrub and swampland in preference to pasture and crop lands. This was confirmed by ultrasonic bat call survey data. It appears that land use change in the form of drainage of once extensive wetlands and vegetation clearance, are responsible for a reduced carrying capacity for this, and probably other, bat species.

Is autumn swarming in bats important in maintaining genetic diversity?

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Many species of temperate bats spend the summer in small sex-biased groups before both sexes move to hibernation caves for winter. In the autumn, prior to hibernation, large numbers of bats ‘swarm’ in and around cave and mine entrances. Although this behaviour is known to be a mating event, we know little about its role in determining the structure of bat populations. We are investigating the swarming of Natterer’s bats, *Myotis nattereri*, at caves in the North York Moors National Park, UK, using a combination of ringing and microsatellite analysis of wing biopsy samples. Low FST and high genetic diversity at nursery and swarming sites, and the movement of ringed bats between nursery and swarming sites, all suggest that swarming is an important mating event that plays a crucial role in maintaining genetic diversity. However, there is significant genetic differentiation between summer populations. The catchment area of these caves is at least 60 km in radius and an estimated 6-8,000 *M. nattereri* visit in the autumn. Bats sampled from three swarming caves in the Yorkshire Dales National Park, over 60 km to the west, were genetically significantly different and are probably part of a separate catchment.

Back to the future – flying fox conservation in orchard systems in Queensland, Australia

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In Queensland there are four species of flying foxes that are both, protected under State legislation and the subject of management programs that include lethal control for crop protection. The recent listing of two of these species as vulnerable under federal legislation has added to a growing controversy over allowing the killing of vulnerable listed species for crop protection. Flying foxes can cause serious damage to fruit crops and for decades little protection was awarded to the animals. Crop protection was usually aimed at killing flying foxes in the orchard or at roost sites. Indiscriminate killing, in combination with habitat loss have been the major contributors in the large population decline. Over the past few years, issues regarding sustainability and animal welfare have led to a change in our management approach by making better use of the scientific and technical information at our disposal. Working closely with growers and industry this approach has led to an increase in the development of various crop protection systems that rely on exclusion and deterrence rather that killing wildlife. To gain a better understanding of the distribution and movements of flying foxes annual broadscale population surveys began in 2002. These data, in combination with historical data have allowed the implementation of a management approach that minimises flying fox mortality in orchard systems. This approach represents the first step in the development of a long-term integrated management strategy to address sustainable crop protection, urban camp management and the protection of roosting and foraging habitat.

Ecological requirements and habitat use of the pond bat *Myotis dasycneme* (Boie 1825)

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The main aim of the project has been finding and protecting the location and hunting grounds of pond bat colonies in the province of South Holland, a district with great economic activity and a rapidly expanding human population and urbanisation. Special attention has been paid to the ecological requirements and habitat use of this species, with an emphasis on the timing and duration of the mating season. The first year (2002) was mainly dedicated to telemetry. Eight pond bats were caught and traced by telemetry during several nights (an average of 10 nights per bat). One large roost was found in the village of Stompwijk. This roost consisted mainly of adult males. During the next two years (2003, 2004) another 10 pond bats were followed by telemetry and four new maternity roosts were found, as well as a few mating roosts. In addition, 15 flight paths to and from hunting areas of pond bats were monitored every month during the season (from April until September) and a large number of bats passing below bridges were caught. This way information on sex-ratio on the hunting grounds, reproductive status of the animals and reproductive success were gathered. All captured bats were individually marked with rings and pit-tags. With this method the dispersion and exchange of individuals between colonies could be monitored. We now have 700 marked pond bats, of which we have obtained 500 re-captures in the field, 400 in the winter quarters and 4,000 by means of automatic pit-tag readers at the colony roosts. The mating roosts of pond bats seemed to be concentrated along the coast of South Holland. Mating roosts were found both in houses and in casemates in the coastal dunes, the latter constructed during the Second World War and now used as hibernation sites by large numbers of pond bats. The mating roosts are thus situated on or near the end of the migration routes of the bats to their hibernation quarters. Some of these mating roost, for example the roost in Stompwijk and the casemates, are occupied by males almost the whole year and visited between August and October by several females, before flying to their OWN and largely UNKNOWN winter quarters. I emphasize the words OWN and UNKNOWN, because the sex-ratio of the animals hibernating in the casemates is skewed in favour of the males (>70%), with a re-capture percentage of 60%. Only few females (0.5%) from the maternity roosts studied were found hibernating: six in the Netherlands/Belgium province of Limburg (in the south-east), and three in adjacent

Germany (in the east).

Conservation of Melanesian Island Archipelago *Pteropus* and *Pteralopex:* preliminary application of IUCN Threatened Species Criteria to subspecies

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Islands of the Melanesian Archipelago provide the perfect stepping stones for *Pteropus* flying fox and *Pteralopex* monkey faced bat speciation. From Papua New Guinea's offshore Islands, Solomon Is., Vanuatu, New Caledonia, Fiji, a spectacular speciation of *Pteropus* across a small but dispersed land area has occurred in mosaics of fragmented habitat, in the form of thousands of islands from a few hectares to 36,000 km^2, dotted over the ocean expanse, from 2,600 m grass-topped peaks to flat atolls separated from neighbouring islands by meters to more than 500 km. Assessing conservation status is crucial in highlighting their little known plight. Six *Pteralopex* spp. and 19 *Pteropus* spp. are recognised (one per 4,000 km^2 of island) 85% endemic. The 2002 IUCN red list recognises 60% (of 20 listed) as threatened at species level, 4 unlisted and no extinctions in the region. In other island regions five *Pteropus* spp. extinctions are reported. Of 44 subspecies (1 per 50 km × 50 km of land), 80% derive a preliminary threatened ranking in this study. Listing deficiencies are due in part to taxonomic uncertainty and a lack of information. Many subspecies populations are isolated by large expanses of ocean, assessment at this taxonomic level better reflects true conservation management units. Island size, range, abundance and analogue population information can provide data that is unlikely to accumulate in the near future through field study. Conservation priorities in the region must also be set against a rapidly changing and clearly delineated environment overlaid by diverse cultures and an expanding human population.

Foraging habitat and insect preferences in serotine bats in relation to variations in land use

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Two maternity colonies of serotine bats, *Eptesicus serotinus,* were studied in contrasting landscapes in Saarland, Southwest Germany, and in the Grand Duchy of Luxembourg. The first was surrounded by mixed woodland, the second by fields and grassland. The aims were to compare the available land cover around the two roosts with the preferred foraging habitats and, for the Luxembourg colony, to compare insect availability with bat diet to determine preferred prey taxa in relation to habitat type. Radio-tracking established the feeding habitats of the colonies and the time bats spent there. From 1996 to 1998 a multidisciplinary project about insect availability in the feeding habitats of the serotine bat colony was carried out by the National Museum of Natural History in Luxembourg. The home range of the colony was determined and in every 1 km grid of the home range, three sets of insect traps were put out for five consecutive nights during three periods of the summer. Parallel to the insect trapping, faeces were collected in the roost and analysed by insect taxonomists. Comparison of faecal analyses and insect availability showed which insects were preferred. The two colonies selected similar foraging habitats, although the available habitats differed greatly. Those were woodland, permanent grassland and settlement area. The bats remained loyal to their main feeding habitats throughout the study. The serotines of the colony in Luxembourg were more selective feeders, eating mainly six insect groups (about 10 species) and varying the composition of their diet according to availability throughout the summer. The foraging habitats were chosen according to the absolute densities and variety of the preferred prey taxa, which were associated with semi-open and open habitats such as hay meadows and cattle pastures with tree groups or adjacent to woodland.

Plasticity in habitat use by *Eptesicus nilssonii* in an anthropogenically-altered environment

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Eptesicus nilssonii is abundant in Scandinavia and Eastern Europe but only sparsely and patchily distributed in Germany. It has been described to hunt in anthropogenically altered habitats such as lamp-lit streets or eutrophic lakes. A radio-tracking study was conducted at Bad Grund (Lower Saxony) to quantify the importance of natural versus anthropogenically altered habitats for and to examine individual habitat preferences of *E. nilssonii*. To answer these questions, three male and ten female bats were marked individually with reflective tape and radio-tagged in front of a maternity roost, and followed using the homing-in-on-the-bat method. Foraging locations were determined with a precision of 25 m. Individual home ranges were calculated using GIS Arc View (Ver. 3.3). Median home range size (interquartiles) was 524 (217–732) ha. Home ranges overlapped widely and extended mostly at altitude levels below the maternity roost. Habitat use showed seasonal variations: forest habitats were used as expected from the habitat composition within home ranges before the young were born but significantly avoided thereafter ($n = 6$, chi-square = 513–6,888, $P < 0.001$). Urban habitats, especially streetlamp alleys, were mainly used by females tagged after the birth of the young. In addition, pronounced individual differences in the use of forest and urban habitats were found. Considering the higher number of intraspecific compared to interspecific encounters in urban areas, these differences may serve to avoid intraspecific competition. Thus, our study provides first evidence that the use of urban habitats by *E. nilssonii* is seasonally limited and is subject to individual strategies.

The diet of greater mouse-eared bat, *Myotis myotis* (Chiroptera: Vespertilionidae), from the colony in Sulejów (Central Poland)

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The greater mouse-eared bat is one of the few European bat species specializing in predating epigeic, wingless invertebrates, including ground beetles. It catches the prey on various surfaces like ground or plants (substrate gleaner). To estimate the frequency of invertebrates groups in the diet of *Myotis myotis* we investigated 380 guano pellets. Material was collected every two weeks (20 pellets) during two breeding seasons (2002 and 2003) in Sulejów, Central Poland. Frequency analysis revealed that Coleoptera occurred in 99% of all checked samples. Among beetle families, Carabidae were the most numerous group (range: 55–100% depending on the season), followed by Scarabaeidae (range: 5–25%) and Silphidae (present only in one sample). Ground beetles were represented by 5 large and medium-sized species (1–2.5cm): *Carabus auronitens*, *C. arcensis*, *C. granulatus*, *C. violaceus*, and *Pterostichus* sp. (probably *P. niger*). The second important group were spiders (Aranea) found in 24% of pellets. Moths (Lepidoptera) were eaten sporadically by this bat species there. Surprisingly we did not confirm the occurrence of any Orthopterans in studied material.

Optimising localisation performance in echolocation

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Echolocating bats obtain three-dimensional images of their surroundings in complete darkness by emitting sonar signals and evaluating returning echoes. When flying close to objects, bats risk collision and therefore depend on the accuracy of images – particularly in the perceived distance of obstacles, which is coded by the time delay between call and echo. Yet, during flight, such accuracy is perturbed first because bats call and receive echoes at different positions and second because echoes are modified by Doppler shifts. Certain call designs avoid both sources of ranging error, but only for a limited range of distances (the ‘distance of focus’; DOF). Here we show that bats using broadband echolocation calls adjust call design in a range-dependent manner so that nearby obstacles are localized accurately. Such behaviour is adaptive because it reduces collision risk. Bats also reduce call duration as they approach obstacles to avoid overlap between target echo and outgoing pulse. Both duration and bandwidth of calls influence DOF independently, with lower bandwidths and longer residual durations giving greater DOF. Our findings give a new perspective on the adaptive significance of echolocation call design in nature, and have implications for sonar engineering.

Sensory systems and spatial memory in the megachiropteran bat *Rousettus aegyptiacus*

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Rousettus aegyptiacus is able to orient using vision or echolocation. These two sensory systems have different processing constraints, which may lead to differences in the way *R. aegyptiacus* uses landmarks to remember locations in space when using vision or echolocation. In addition little is known about the way different sensory systems that indicate the same thing interact, in this case the location of landmarks in space. Does learning about a location in space using vision allow a bat to remember that location when only echolocation is available? Here we present data that demonstrates that *R. aegyptiacus* uses the same spatial memory mechanism to learn the location of a perching place when only vision is available and when only echolocation is available. However, learning about a location when only vision is available does not allow the animal to perform the task when only echolocation is available, the task must be relearned.

Pre-hibernal and hibernal activity and dispersal patterns of Leisler's bat, *Nyctalus leisleri,* in Northern Ireland

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The pre-hibernal and hibernal activity of Leisler's bats, *Nyctalus leisleri*, was investigated in Northern Ireland using radiotelemetry. Twenty-nine adult bats were tagged using temperature sensitive transmitters and tracked for 196 nights during 2002 and 2003. Overall time spent roosting gradually increased from mid-August until the start of November and after the first week in November, when temperatures reach around 10°C, bats spent all of their time in the roost. Mean skin temperature of roosting bats decreases rapidly from mid-September to mid-October. After this period, the pattern of variation in skin temperature matches that of ambient temperature. Although houses, unoccupied buildings, trees and bat boxes were occupied by bats, trees (primarily oak and beech) were used almost exclusively after the start of November. Mean male roosting skin temperature was about 3°C warmer than females suggesting that males were more active in the roosts than females. Skin temperature of roosting bats increased rapidly just after sunset and peaked sharply three hours after sunset decreasing back to pre-sunset levels five hours after sunset. Bat activity ceased below an ambient temperature of 6°C. Bats moved, on average, about 2 km in a southerly direction and the largest distance travelled between roosts was 34 km. Large-scale dispersal, or migration, was not evident. The implications for conservation of species are discussed.

Why tribosphenic? On mystery of chiropteran teeth

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The tribosphenic molar, a synapomorphy of all mammalian clades, is retained and with few clade-specific modifications strictly conserved in nearly all microbats. Our contribution is intended to discuss why just such a type of dental arrangements is so constant and why possible variations on it are largely constrained. We reexamined state of 22 fine dental characters in 60 taxa of vespertilionid bats and in some of them also investigated micromorphology of the molar enamel coat with particular respect to the patterns of enamel maturation. The results suggest that the major goal of tribosphenic organisation is in its modular structure and in that the respective structural modules interface at broad suture zones. In combination with delayed enamel maturation this allows extensive spatial rearrangements during late odonotogenesis and the perieruptional enlargements of the tooth, which produce a maximisation of adult occusion space. Moreover, heterochrony of the enamel maturation and delayed final setting of the tooth design also allows a fine response of adult tooth design to the most derived rearrangements of the dental and oro-facial context (i.e. the rearrangements appearing late in ontogeny) and, hence, a very rapid and effective adaptive microevolution (within the functional limits of tribosphenic design).

Phylogeography *of Pipistrellus pipistrellus* / *P. pygmaeus* complex (Chiroptera: Vespertilionidae)

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The recent situation in *Pipistrellus pipistrellus* / *P. pygmaeus* complex is characterized by (a) considerable morphologic similarity, (b) different design of echolocation calls – 45 and 55 kHz, (c) genetic distance about 11% based on mtDNA, and (d) broad co-distribution of both forms over most of the European range. In order to reconstruct the history of this assemblage, we performed phylogeographic analysis based on 402 bp portion of cytochrome b gene from 68 pipistrelle bats representing the whole range. The accent on filling gaps in geographic sampling enabled us to discover further cryptic variability within the complex in Libya and Morocco. The resultant phylogenetic tree consists of clade I (*P. pygmaeus* s. str. and Libyan samples) and clade II (*P. pipistrellus* s. str. and Moroccan samples). The distance of Libyan population (5–7% from *P. pygmaeus* s. str.) suggests its species status. The species status of Moroccan population is also discussed. The genealogical structure is relatively low (almost absent in *P. pygmaeus* s. str.) in European forms, which largely contrasts with deep divergences in the Mediterranean region. Based on discovered phylogeographic patterns, we proposed the allopatric speciation model of main lineages with Mediterranean region as the source area. These outcomes were further corroborated with molecular clock estimations (correlation with Messinian salinity crisis), analysis of echolocation calls, morphology and the fossil record.

Comparing chiropteran colliculi: neuroanatomical correlates of bat sensory ecology and foraging strategy

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Variations in sizes of superior and inferior colliculi, olfactory bulb, and auditory nuclei were examined using a data set for 140 species of bats. Using both conventional and phylogenetically based analysis of covariance (log body mass as covariate), I tested several hypotheses that relate the sizes of the colliculi to variation in foraging ecology, categorized here as phytophagous and insectivorous. In some analyses, the category phytophagous was split into phytophagous pteropodid and phytophagous phyllostomid to examine differences between two distinct clades of bats. Because the Megachiroptera orient primarily by vision and olfaction, whereas all other bats rely on laryngeal echolocation to locate their prey, I hypothesized the superior colliculus of phytophagous bats should account for a larger proportion of the total volume of the corpora quadrigemina than in insectivores. This hypothesis was supported by these analyses. I also examined the relationship in volume of olfactory bulb and auditory nuclei to the proportional size of the superior colliculus and conclude that there is some evidence for a positive association between superior colliculus and olfactory bulb size.

A moveable face: deconstructing microbat phylogeny

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The microchiropteran infraorders Yinochiroptera and Yangochiroptera were established by Koopman in 1985 in an effort to apply cladistic methodology to bat classification. The primary basis for Koopman's groups was the premaxilla, which Koopman asserted to be loosely attached to the maxilla, or moveable, in the Yinochiroptera and fused to the maxilla, or immobile, in the Yangochiroptera. Thus one of his infraorders is necessarily based on symplesiomorphy. Notwithstanding, we consider the utility of the premaxillary dichotomy in terms of consistency within groups as well as functional significance; and in light of molecular evidence that some yinochiropterans may be specially related to megachiropterans, whilst others are more nearly affiliated with yangochiropterans. We also review names applied to the groups of bats, particularly at the sub- and infraordinal levels, concluding that current appellations – including the neologism Yinpterochiroptera – no longer embody the authors' implied groups or have been so frequently redefined as to be positively misleading. We therefore propose the new subordinal names Vespertilioniformes and Pteropodiformes, which are based strictly on the oldest generic names for included taxa (respectively *Vespertilio* Linnaeus, 1758 and *Pteropus* Erxleben, 1777) and are thus virtually impervious to pre-emption. We also indicate the content of each suborder.

The secret life of the long-fingered bat (*Myotis capaccinii*) on the Balkans: conservation applications

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Results from a long-term study on the distribution and population size of *Myotis capaccinii* on the territory of Bulgaria are presented. Roost preferences of breeding and hibernating colonies were analysed based on data from more then 80 localities. New data on the structure of summer colonies and seasonal movements are presented. Monitoring methodologies and conservation application of the gathered data are discussed.

Sympatric speciation in the insectivorous bat *Scotophilus dinganii*

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We investigated the possibility of the existence of a cryptic species within *Scotophilus dinganii* by sampling *Scotophilus* at two sites in South Africa and three sites in Zambia. Here we show that 1) there are two forms of *Scotophilus* with yellow venters – a smaller form with a forearm of 45–52 mm and a larger form with a forearm of 51–60 mm; 2) the two forms differ in their echolocation behaviour – the smaller form has a peak echolocation frequency of 44 kHz that differs from that used by the larger form (33 kHz) and *S. viridis* (40 kHz); 3) the 44 kHz and 33 kHz *Scotophilus* differ in their cytochrome b sequences by an average of 3.4% and both differ from *S. viridis* by an average of 8.9% and 8.6%, respectively; and 4) the 44 and 33 kHz *Scotophilus* are sympatric. The forearm and peak echolocation frequency of the 33 kHz *Scotophilus* is the same as that of *S. dinganii*. On the other hand, although the 44 kHz *Scotophilus* is similar in size to *S. viridis* it differs from *S. viridis* genetically, in its echolocation

behaviour and in its yellow venter. We thus propose that the 44 kHz *Scotophilus* and the currently recognized *S. dinganii* are sibling species and that sympatric speciation was possibly mediated by disruptive selection on body size and/or echolocation.

INTERREG IIIA projects "Bat conservation in the Alpine and Adriatic region" (Austria-Italy-Slovenia)

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We initiated two INTERREG IIIA projects for transboundary cooperation in bat conservation based on the results of several bat conservation projects conducted in Austria between 1999 and 2002. The project region comprises Austria (Carinthia, Salzburg, Tyrol), Italy (South Tyrol) and Slovenia. The Arge NATURSCHUTZ in Carinthia (Austria) is acting as lead partner during the period from 2003 to 2006. The goals of the two INTERREG projects include extensive bat conservation measures for summer and winter roosts as well as for foraging habitats: conservation of roosts and foraging habitats of endangered bat species; monitoring of colonies; preparation and implementation of a standardised monitoring program for bat populations; study of roost utilisation and habitat preferences to provide basic knowledge for long-term conservation strategies; implementation of conservation measures; assistance during renovations of roosts, providing advice in case of bat-induced problems and handling of injured individuals; information and education of the public to improve the acceptance of bats; training of volunteer bat workers.

Bats, clocks and rocks: diversification patterns in Chiroptera

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Understanding if species are unevenly distributed across clades is critical for explaining the evolutionary processes of biodiversity as well as preserving the tree of life. For the first time, we quantitatively explore patterns in diversification among the second largest order of mammals, the bats (Chiroptera). We use whole-tree methods that exploit the topological distribution of species diversity and temporal methods that exploit the distribution of speciation events through time. Under multiple statistical models, we show that bat among-lineage diversification rate has not been constant and shows more heterogeneity than other mammalian clades thus far studied. Whole-tree likelihood-based relative rates tests suggest that clades within the families Phyllostomidae and Molossidae underwent a number of significant relative changes in diversification rate. There is also some evidence for rate shifts within Pteropodidae, Emballonuridae, Rhinolophidae, Hipposideridae and Vespertilionidae, although the significance of these shifts depends on polytomy resolution within each family. Diversification rate in bats has also not been constant, with the number of lineages through time revealing that the greatest diversification rate occurred around 25–35 million years ago, a time coinciding with a rapid diversification in the flowering plants.

Genetic structure in serotine bats, *Eptesicus serotinus*, at two different geographic scales from mtDNA sequences

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The main goal of this project is to investigate the social structure of the serotine bat, *Eptesicus serotinus*. We have studied the genetic structure among different populations of serotines using a highly variable mitochondrial DNA fragment (D-loop) and at different geographic scales: first, between Morocco and Iberia and secondly among colonies in southern Spain. A 500 bp fragment of the HV1 region was sequenced and aligned for a total of 244 bats belonging to 12 different colonies from Andalusia (southern Spain) and Morocco. Data were analyzed from both phylogenetic and network approaches. Preliminary results suggest on one hand, a high genetic similarity between Andalusia and northern Morocco. On the other hand, Andalusian populations showed a high variation in their haplotypes diversity and genetic structure, despite being some of them only a few kilometers apart. In fact, fixation indexes indicate that females, at least, show high phylopatry and colony fidelity.

Flexibility and stability: historical and ecological correlates of dietary diversity in Neotropical leaf-nosed bats (Phyllostomidae)

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Neotropical leaf-nosed bats represent, with more than 150 species and a broad dietary spectrum ranging from blood, arthropods, and small vertebrates to fruits, nectar, and even leaves, ecologically the most diverse group of mammals. Dietary specialisation as a crucial factor driving diversity is well-reflected in the structure of local species assemblages. Species assemblages of phyllostomid bats are composed of discrete trophic groups even though the diet of individual bats may vary strongly with season and locality. The combination of long-term data from a local bat assemblage in Panama consisting of more than 3,800 dietary records from 30 syntopic species with food choice experiments, infrared surveillance of composition, handling, and processing of prey, nutritional analysis, and food availability as well as long-term sampling of prey remains at nightly feeding roosts permit a comprehensive, multi-level analysis. Linking diet selection to ecological, morphological, and physiological adaptations including phylogenetic relationships reveal that overall trophic structure of phyllostomid bats is mainly determined historically, whereas within-guild structure mostly reflects local resource availability and species-interactions. Within animalivorous phyllostomid bats, we found a gradient-like dietary structure across species that contrasts with previous views that postulated the species-specific use of many independent discrete resources. Further, it is likely that carnivory is an extreme of animalivory rather than a qualitatively distinct feeding habit. This conclusion is in accordance with morphological data indicating that carnivorous phyllostomid bats are bigger and only modestly modified versions of soft-insect specialists.

Sniffing it out: sensory ecology of fruit-eating bats

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Fruit-eating bats (Chiroptera) face several sensorial challenges when searching for food. They have to detect, identify, and localize fruit in clutter-rich environments such as forest canopies or dense understories. Often, fruits are nestled among leaves. This makes detection by echolocation particularly difficult as echoes from the background overlap with echoes from the fruit and also complicates use of visual cues. Taking several bat-dispersed plants as an example I show how plants “advertise” their fruits to bats and how bats use multi-modal cues to find, classify, and select among fruits. Examples range from 1) figs (*Ficus* sp.) where large number of fruits ripen synchronously over a few nights broadcasting species-specific odour plumes to attract bats or where fruits change colour when ripe and are exposed on leafless branches or trunks to 2) pepper plants (Piperaceae) with spike-like fruit stands that attract bats with a combination of scent and a characteristic shape facilitating localisation by echolocation and 3) to fruits of a curcubid vine (*Gurania* sp.) that dangle in open space between canopy and subcanopy, offering echo-cues to foraging bats. In frugivorous Microchiroptera, echolocation plays in addition to olfaction and to a limited degree vision an important role for localisation and in part also for detection of ripe fruit. In contrast, Megachiroptera rely entirely on visual and olfactory cues for finding ripe fruits. These sensorial differences are well-reflected in different fruit-syndromes of plants such as figs that are dispersed by both, Micro- and Megachiroptera.

Roosting and population ecology of three sympatric tree-dwelling bat species (*Myotis nattereri*, *M. dabentonii* and *Nyctalus noctula*)

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Bat community was studied in selected small park area surrounded by agricultural land in southern central Slovakia in 2001–2004. Breeding colonies of three bat species (*Myotis nattereri*, *M. daubentonii* and *Nyctalus noctula*) were roosting in tree-hollows. The data of tree-hollow occupancy, population, size and composition, breeding phenology and activity were collected by harp-trapping during evening emerging, observations of dawn swarming, visual hollow inspections, using of chemiluminiscent tags, mist-nettings and ringing of all capture individuals. With respect to roost site supply and interspecific competition (including also other tree-hollow dweller groups of animals), the roost site selection and microhabitat preferences were investigated in mentioned bat species. Predation of bats, connection between roosting and foraging habitats and presence of other bat species living in the study park area were registered, too. Thanks to a large number tree-hollows, the park is an important habitat for tree-dwelling bats. It also significantly contributes to the biodiversity in the landscape.

Thermoregulation in nectarivorous bats: how to respond when the nectar runs dry?

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In the Neotropics glossophagine bats occur in various habitats over a wide elevational gradient, and many species are highly specialized in their exploitation of floral nectar. These bats have some of the highest metabolic rates in mammals, due in part to the substantial energetic costs of flight and thermoregulation, and thus are particularly susceptible to sudden drops in food availability. Although the tropics are commonly perceived as being a region of plentiful food resources and favourable climate year round, these animals are in fact frequently exposed to periods of food restriction and adverse climate. To face such unfavourable conditions, they have evolved different behavioural adaptations, among which seasonal migrations and shifts in diet are recognized. This study addressed the question of whether glossophagine bats can also respond to adverse conditions by reducing their metabolism. This strategy is commonly observed in temperate species and hitherto not well understood in nectarivorous bats. Respirometry and telemetric measurements of body-temperature were employed to record the physiological response of *Glossophaga soricina* to changes in both ambient temperature and food availability in the laboratory. Normothermia was maintained independently of ambient temperature when sufficient food was offered. The animals commonly went into shallow hypothermia when food availability was mildly restricted. When the costs of flight and thermoregulation exceeded energy uptake, true torpor with drops in body-temperature of more than 15°C was recorded. Energetic savings during torpor were considerable. In summary, I conclude that hypothermia, as a behavioural strategy for surviving periods of food shortage, may also be an important adaptation in nectarivorous bats.

Co-operation in bats: information transfer in colonies of the Bechstein's bat

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In many taxa our understanding of the evolution of sociality is based on an extensive research body, but there are exceptions. The diverse order of Chiroptera is such an exception. But although detailed studies of bat social behaviour are uncommon, examples of striking co-operative behaviours, such as food-sharing, allo-nursing, and information transfer, have been described. Thus, co-operation with group members may be one important intrinsic benefit of group living in some species. In my talk, I first will briefly review the present knowledge of co-operation in bats and concentrate on information transfer in Bechstein's bats, *Myotis bechsteinii*, then. Coloniality in bats has been explained by the argument that communal roosts serve as information centres where colony members transfer knowledge about their habitat. I tested whether female Bechstein's bats living together in a breeding colony exchange information about roosts. In a field experiment, I offered individually PIT-tagged females suitable versus unsuitable roosts, which were constantly monitored with PIT-tag readers. The arrival pattern of individuals revealed that colony members exchange information about novel roosts among each other. Information transfer was not reciprocal and it was not influenced by the degree of relatedness among colony members. In conclusion, female Bechstein's bats may profit from sociality because colonies build up a communal knowledge about roosting sites. Because colonies are closed societies, where individuals live together for many years, non-reciprocal information transfer may be stabilised by long-term benefits and group augmentation.

Gene flow versus bat news – why do bats swarm at underground sites?

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During late summer thousands of bats may swarm in front of subterranean hibernacula. Swarming bat communities are highly divers in terms of species composition, age and sex. Usually, males outnumber females, and both sexes may be faithful to once selected swarming sites. Automatic registration (double light barrier) at a German mass hibernaculum indicates two phases of swarming. During the first phase of high swarming activity in- and out-flights are balanced, while the number of out-flights decreases relative to in-flights in the second phase, resulting in a steady increase of the resident population. Nevertheless, the number of swarming bats is much higher than the number of actually hibernating bats. Our combined analyses of ecological and molecular data for brown long-eared bats unambiguously show that swarming behaviour may provide the opportunity for gene flow across colony borders. Individual relatedness was significantly higher at nursery colonies compared to swarming sites. However, despite behavioural and physiological evidence for sexual interaction at swarming sites, this does not sufficiently explain why mating continues throughout the winter. We therefore discuss the evolution of bat swarming behaviour also in the context of information transfer within and among colonies and species.

The effect of ambient temperature inside and outside of hibernacula on the timing of onset of hibernation and arousal in *Myotis formosus*

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Myotis formosus, mainly distributed in eastern Asia, has not been fully studied yet. In Korea, it is listed as an endangered species. The study on the timing of onset of hibernation and arousal of *M. formosus* in relation to the ambient temperature was conducted from October 2000 to December 2003 in mines of Hampyeong-gun, Korea. *Myotis formosus* enter torpor or hibernation to survive frigid winter. In winter, the ambient temperature inside of hibernacula was warmer and less fluctuated than those of hibernacula outside. The ambient temperature inside of the hibernacula used by *M. formosus* was higher and more stable than those of non-hibernating roosts. The mean temperature of the hibernacula inside was 2.6 ± 0.34°C. The temperature of the hibernacula used by *M. formosus* was higher than those of other *Myotis* genus or Greater Horseshoe Bats (6–8°C). *Myotis formosus* arrived in hibernacula from early October, and the peak number was made in the mid-October. From late May to early June in the next year, bats left at these sites. The timing of onset of hibernation and arousal in *M. formosus* were significantly related to the reversion timing of the temperature of hibernacula inside and outside. *Myotis formosus* began to hibernate when the temperature (minimum) of outside of hibernacula became lower than those of inside; on the other hand the opposite was true in arousal.

"Nietoperek" Bat Reserve; the origin, current protection status, importance for bats and bat research

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The Mi□dzyrzecz Fortified Front was built by the Germans in the 30s and during World War II. Its central sector, 15 km long, was especially studded with the above-ground fortification objects connected by an underground system of corridors of total length of ca. 32 km. After World War II the underground fortifications were deserted and became the largest bat hibernaculum in Poland. The bat protection began in 1980. Within the last 24 years all underground corridors and most of the entrances became protected as reserve "Nietoperek II", the "Management Plan" was accepted (2000) and the area surrounding underground fortifications became protected as well. The aim of protection of the sufrace area is to preserve the bat's maternity colonies, feeding grounds and migratory routes. Thirteen species (*Myotis bechsteinii*, *M. brandtii*, *M. dasycneme*, *M. daubentonii*, *M. myotis*, *M. mystacinus*, *M. nattereri*, *Pipistrellus pipistrellus*, *Eptesicus serotinus*, *E. nilssonii*, *Barbastella barbastellus*, *Plecotus auritus* and *P. austriacus)* were found hibernating in "Nietoperek". Since 1998 winter bat censuses are made once every two years, during one day, from the sunrise to sunset, by 10 groups of bat workers, mainly volunteers, counting animals simultaneously in the different parts of underground system. This method makes possible to minimise the disturbance and an error associated with their movements caused by observers. In January 2003, 25,339 individuals of 11 species were recorded. During the last two years the decline in the number of wintering bats was estimated at ca. 12%. Currently the study on sex and age related habitat selection, fat accumulation and winter feeding are carried out.

How to distinguish between two sibling species, *Myotis ikonnikovi* and *M. mystacinus*

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In Japan, there are nine species of the genus *Myotis* (Maeda, 1994, Maeda and Matsumura, 1998). In north island of Japan, Hokkaido, six species of the genus *Myotis*, including two sibling species *M. ikonnikovi* and *Myotis* sp. (*M. mystacinus* from Japan), are distributed. Because the two species has been categorized as the endangered according to Japanese Red Data Book (Ministry of the Environment 2002), it is necessary to obtain their precise information, such as distribution pattern, habitat ecology and population size, with little destruction. The braincase shape has been the most useful characters for identifying those species (Maeda, 1994), but it is difficult to identify the two species without killing. To establish the method for identifying these two species, we defined new external characters as differential pattern of blood vessel in membrane. The study of molecular phylogeny suggests that the two species are different descendants; *Myotis* sp. from Hokkaido is included in the American clade, and *M. ikonnikovi* is the member of clade from Palaearctic region (Kawai *et al*., 2003). By using biopsies whose the mitochondrial DNA sequence we obtained, we confirmed that this external character is an apomorphy exactly to distinguish between these two species in non-lethal method.

Does ethanol in ripe fruit serve as an olfactory cue and/or as an appetitive stimulant to Egyptian fruit bats, *Rousettus aegyptiacus*

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Fruit is central to the diet of many frugivorous bats. Because the nutritional contents of food vary with respect to odor, color and texture, the sensation and perception of these may be relevant cues in the feeding ecology of frugivorous bats. In fleshy fruit, for instance, color and sugar concentrations may change during the ripening process. Sugars, in turn, are fermented by yeasts to produce alcohols, predominated by ethanol to which bat olfaction may be sensitive. We studied the role of ethanol as an olfactory cue for detection of ripe fruit by the Egyptian fruit bat, *Rousettus aegyptiacus*, and its possible role as an appetitive stimulant. In odor preference experiments, we observed that ethanol (in mango juice) at concentrations > 1% deterred the bats from feeding. The effects of ethanol on appetite changed with season. During summer, food consumption of an artificial liquid food preparation containing low concentrations of ethanol (0.01%; 0.1%; 0.5%) did not differ significantly from consumption of the control diet (no ethanol), whereas at higher ethanol concentrations (1% and 2 % v/v), food consumption decreased significantly. During winter, food consumption at low concentrations (0.1%; 0.3%; 0.5%) was significantly lower than of the control diet. Our data indicate that Egyptian fruit bats can use the odor of ethanol to assess food suitability, and that ethanol elicits avoidance at concentrations greater than 1%, which often characterizes overripe and unpalatable fruit.

Feasibility of active flight in bats: prerequisites and consequences

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The aim of the present study was to establish the prerequisites (morphological, ecological, and ethological) indispensable for realization of active flight in bats, their consequences, and to reveal the reasons of distinctions in morphology and behaviour of the studied groups of bats. The main morphological differences of respiratory systems of actively flying vertebrates, in particular bats, from non-flying ones, were searched in organs of external breathing. Material used was composed of representatives of two bat families (Rhinolophidae and Vespertilionidae), and some non-flying mammals (Insectivora, Primates). Different data on bat echolocation, ethology, and types of locomotion, plus some environmental factors (especially the Earth's gravity), were also taken into account. We concluded that respiratory-motor organs of external breathing (thoracic cage, ventral-thoracic musculation, diaphragm) and lungs in bats differ in relation to: 1) the usage of different types of locomotion; 2) arrangement of the centerline of an animal's body with regard to the vector of gravitation and duration of their co-directivity; 3) usage of different echolocation systems. We developed our hypothesis put forward in 1994, that the decisive prerequisite for realizing active flight in bats was a wing membrane, which functions not only as an organ of locomotion, but also as an organ of external breathing, and, alongside with pulmonary structures, represents a vast diffusive surface.

Bacular morphology in some Asiatic *Myotis*

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Morphology of baculum plays a significant role in solving certain problems of bat taxonomy, especially those connected with relations between similar species (e.g., Hill and Harrison, 1987; Strelkov, 1989). Herein we describe penial bones of some *Myotis* spp. (members of the most complex vespertilionid genus), which have not been described in literature: *Myotis macrodactylus*: baculum ca. 0.9

mm in length, only slightly narrowing to the distal end, slightly curved upwards, with prominent basal notch and urethral groove. Eastern water bat (provisionally named *M. petax*): baculum 1.15–1.6 mm in length (nearly twice larger than in *M. daubentonii*), not distinctly narrowing to the tip, with a deep basal notch, up to 0.5 mm, and distinct urethral groove. *Myotis horsfieldi*: baculum ca. 0.75 mm in length, parallel-sided, narrowing only in its distal third, with a shallow basal notch and prominent urethral groove. *Myotis csorbai*: baculum very small, ca. 0.4 mm in length, relatively wide at base, almost triangular in shape, with medium-sized basal notch and shallow urethral groove (very distinct from the baculum of the taxonomically related *M. annamiticus*; see Kruskop and Tsytsulina, 2001). *Myotis rosetti*: baculum ca. 1.15 mm in length, relatively wide with wide tip, somewhat curved upwards, without basal notch and with distinct urethral groove. All the described specimens are stored in the collection of Zoological Museum of Moscow State University.

Topical issues of bat taxonomy in Russia
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Within the last decade a definite increase in the number of recognized bat species is being observed worldwide, also including Russia and adjacent countries, resulting from the employment of new research techniques and availability of new collection material. Several new species of *Plecotus* were recently recognized in Europe. The presence of the Alpine long-eared bat in Russia was confirmed by Spitzenberger *et al*. (2003), while the status of other forms previously synonymized with *P. austriacus* remains uncertain. Recent revision of the *Myotis mystacinus* group by Tsytsulina (2001) resulted with a double increase in the number of recognized species. Our molecular data have confirmed specific distinctiveness of *M. aurascens*, inhabiting arid regions from Mediterranean to Transbaikalia, and likely to be conspecific with South European *M. alcathoe*. Molecular survey of this group is going on. Amongst other *Myotis* species of Russian fauna, the structure of *M. daubentonii* complex is of doubtless interest. Cranial and bacular morphology and recent molecular data, namely SINE insertions, indicate probable presence of two species. Siberian and East Asian forms should be provisionally united under the name *M. petax*, which is corroborated by the results of investigation of the type specimen photographs. As for the other genera, the presence of the two sibling species in the *Pipistrellus pipistrellus* complex (namely *P. pipistrellus* and *P. pygmaeus*) found additional support, including data from the SINE insertions. The latter species is already known from Caucasus, and likely to occur on the most part of European Russia (based on non-molecular data); appropriate molecular research is ongoing.

Roost selection, social organization, and mating systems in the Chiroptera
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Our understanding of how the roost environment influences social behavior and mating systems in bats is still in its infancy. Research on several species has revealed a wide range of mating systems, including leks, multi-male/multi-female groups, seasonally variable, single male/multi-female aggregations, year-round harems with labile female groups, seasonally variable, multi-male/multi-female groups year round, multi-male/multi-female groups, and monogamy. Available data on both foliage and cavity-roosting species, suggests a predominance of female-biased roosting groups. One hypothesis for the formation of female aggregations is that suitable roost resources are limiting. When breeding females occupy roosts that can be defended by males (mating territories), the potential for polygyny will likely depend on the site fidelity (or group cohesion) of females. Whether females select males on the basis of roost quality or some characteristic of the male is unclear. In most species that have been studied, male mating strategies appear to be based on territorial defense of roosts. In these situations, a polygynous mating system can be attributed largely to variation in behavioral cohesiveness of reproductively active females. Observations of several species suggest that tree cavities, caves with solution cavities, and some types of foliage (including plant parts modified into tents) offer resources that are potentially limiting, but also can be defended mostly by single males. In some species in which large aggregations are known, a subordinate male in a harem group may be tolerated, where they may ultimately assume the status of the dominant male. Observations that other males assemble in bachelor groups suggests that harem males and the subordinate male may prevent other males from gaining access to preferred roosts or female groups during reproductively receptive periods.

Observations of bat hibernation in their northernmost distribution area, in Finland: a review of known hibernation sites and a case study of the phenological fluctuations of bat activity in Heikkilä cave

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The 11 vespertilionid bat species occurring in Finland live near the northern limits of their distribution areas. Sheltered hibernacula are crucial for the survival of bats during the long winter period. So far, very little is known about the hibernation sites and activity patterns of bats in Finland. Data on these topics has been gathered more intensively during the last few years. Most of the known hibernation sites are in Southern and Western Finland and they are occupied by few individuals. *Eptesicus nilssonii* and *Myotis daubentonii* are the most numerous species (ca 90%). Caves, cellars and bunkers seem to be the most important hibernacula types. The phenological changes in bat activity were observed in an abandoned military cave in Turku, Southwestern Finland (60°25'N, 22°15'E). The cave with 46 hibernating *Myotis* spp. individuals was found in March 2002. In the following summer, a passive infrared sensor (PIR) connected to a computer was installed at the entrance. Temperature was measured with data loggers. We got data from March till October 2003 and again from February till May 2004. Bats started to fly 14th April. Activity decreased towards the end of May. There was no activity between June and third week of July. The activity of bats started to increase again in August. The 25 *M. daubentonii*, 4 *M. brandtii/mystacinus,* 1 *M. nattereri* and 1 *Plecotus auritus* were found in the cave during winter 2002–2003. This preliminary study demonstrates the possibilities to obtain usable long time data on bat phenology with relatively cheap equipment.

Variation in choice of day roosts by reproductively-active female long-legged myotis, *Myotis volans* in Ponderosa Pine Forests

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Selection of day roosts by adult female, long-legged myotis, *Myotis volans*, was studied in four watersheds dominated by Ponderosa pine, *Pinus ponderosa*, forests east of the Cascade Crest in Washington and Oregon, USA. A total of 87 bats were radio-tracked to 195 snag roosts and 34 rock roosts encompassing 842 roost-days. Individual bats switched roosts every 2.7 (0.16 SE) days and used 3.6 (0.34) roosts per tracking period. Roosts were 2 (0.1) km from capture sites and bats moved an average of 1.4 (0.11) km between successive roosts. Six bats (6.9%) day-roosted exclusively in rock roosts, nine bats (10.3%) roosted in snags and rock roosts, and the remaining bats (82.8%) roosted exclusively in snags. Most snag roosts were thick-barked Ponderosa pine (52.8%) or thin-barked grand fir, *Abies grandis*, and white fir (*A. concolor*) (37.9%). Flyout counts revealed that 98 snag roosts (52%) were solitary roosts, with 28 snag roosts (14%) housing >50 bats (i.e., large-flyout roosts). Most large-flyout roosts were in thick-barked Ponderosa pine (93%). Bats that were pregnant day-roosted in snags with thin bark, primarily *Abies* spp., for longer periods than in snags with thick bark [3.3 (0.42) vs. 2.4 (0.29) days]. Conversely, lactating bats day-roosted in snags with thick bark, primarily Ponderosa pine, for longer periods than in snags with thin bark [2.7 (0.42) vs. 1.9(0.20) days]. We recommend that forest management targeting reproductively-active, female long-legged myotis in Ponderosa pine forests provide for continued availability of both thin and thick-barked tree species to ensure adequate maternity habitat for these bats.

Bats of French Antilles: elements to recognize them by theirs calls

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During our stay in Martinique in March 2004, we captured and recorded 10 on 11 species of bats, which originated from different families: Noctilionidae, Mormoopidae, Phyllostomidae, Vespertilionidae, Molossidae, and Natalidae. Out of 420 recordings (= 4 hours 30 minutes), only 200 have turned out to be usable for research on the identification criteria of recorded taxa. Thus out of 10 captured species, we only characterized six species and one group of four species. The first elements, which have been collected, permit to differentiate selected species or to characterize some families in a conclusive way. A number of acoustic convergences with the European bats allow us to form a hypothesis on the hunting habitats or on the nutritional specificities. Following these encouraging results, complementary campaigns are thus necessary to go on with the study or with the acoustic identification of 15 species of Chiroptera found in French Antilles (Martinique, Guadeloupe) (or even more widely in West Indies).

Morphological and genetic divergence in Vespertilionid bats

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Studies of inter-population genetic differentiation in bat species indicate a diverse pattern of population genetic structure, with migratory species generally exhibiting less structure than sedentary species. In addition, studies using molecular markers have demonstrated that a number of common species are actually composed of two or more cryptic species that share a similar morphology but have been genetically distinct for long periods of time. We combine analysis of molar tooth shape (using geometric morphometrics) with molecular data to investigate whether levels of morphological differentiation among populations vary in the same way as genetic differentiation. We also consider whether the potentially high rate of gene flow in bats slows the rate of morphological evolution, compared with that seen in other mammals, and whether migratory bat species show lower rates of morphological differentiation than sedentary species. Finally, we investigate at which level (genus, species, population) European bats are identifiable using tooth morphology, with regard to taxonomic identification of palaeontological samples and assessments of past bat biodiversity.

Ectoparasite loads and their impact on the physical condition of Schreiber's bat, *Miniopterus schreibersii*

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Parasitism is often an important constraint of the physical condition of animals. Although bats harbor a wide range of parasites, very little is known about their impact on the condition of these hosts. We studied the seasonal variation of ectoparasite loads on *Miniopterus schreibersii*, and the possible impact of ectoparasites on the physical condition of bats in different phases of their annual cycle. Ectoparasites were regularly collected from 1,040 bats during a full yearly cycle. Five species of bat flies (Nycteribiidae and Streblidae), one tick (Ixocidae) and several species of mites (Macronyssidae and Spinturnicidae) were found. The patterns of seasonal abundance differed among parasite species, but they all tended to be more abundant during the summer. Overall, parasite loads were unrelated to age or sex of the bats, except for pregnant females, which tended to have more parasites. The impact of the parasites on the physical condition of the bats was tested during early hibernation, late hibernation, nursing and mating. In none of these phases of the annual cycle parasites seemed to have a significant impact on the physical condition of the hosts.

Educational campaign about bat conservation in the Alqueva region (southern Portugal)

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The lack of knowledge and negative attitudes towards bats are one of the greatest, and yet, least appreciated threats to this animal group. Indeed, the conservation of bats is not only a biological and ecological matter, but also a social one. Thus, it is essential to promote conservation educational campaigns that help change human perceptions of these species, and give a more informed and publicly acceptable image of bats. This presentation reports the results of an educational campaign, focused on bat conservation, which took place in the Alqueva region. During the year of 2002 a total of 32 schools were visited in the councils of Moura, Mourao, Barrancos, Portel and Reguengos de Monsaraz, and approximately 1890 children had classes about bats. An enquiry was distributed previously and after the campaign, to help examined its effectiveness. Major differences were noticed in children's knowledge and attitudes, revealing the apparent success of the campaign. In addition, it allowed understanding the motives associated with the negative image that children had of bats, which can be targeted in future educational campaigns.

Ecology of three pipistrelle species *P. nathusii, P. pipistrellus* and *P. pygmaeus* in S-Bohemia: habitat use and seasonal changes in activity

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Present work summarizes the results of two-year study (2002–2003) on seasonal changes in activity and habitat use of three pipistrelle species (*P. nathusii, P. pipistrellus* and *P. pygmaeus*) in the České Budějovice pond basin (S-Bohemia, Czech Republic). The course of seasonal flight activity in Vrbenské rybníky pond reserve, which represents an area with syntopic occurrence of all three species, was evaluated by the means of bat detector in the first half of the night. In all pipistrelle species, the highest level of flight activity occurred during the spring and autumn migration and pre-lactation period, while it was relatively low in-between. The time allocation with respect to reproductive period of male social calls has also been analyzed in *P. nathusii* and *P. pygmaeus*, while social calls of *P. pipistrellus* were not recorded in the reserve. Considerable peak in presence of these calls in *P. pygmaeus* has occurred during autumn migration while social calls of *P. nathusii* were recorded throughout the year. The levels of activity of all pipistrelle species were studied in different places of the basin. Ten habitats were recognized: three woodland habitats (broad-leaved, mixed and coniferous forests), two aquatic habitats (reservoirs and rivers), two urban habitats (built-up areas with high and low buildings), meadows, arable land and parks. The presence of aquatic habitats strongly supports high levels of flight activity of all three species. Nevertheless, differences were recorded among the three species: while the flight activity of Soprano pipistrelle and Nathusius' pipistrelle was more confined to water habitats, the Common pipistrelle seems to be less specialized with respect to spectrum of used habitat types. An evidence of spatial separation of males of the two sibling pipistrelle species (*P. pipistrellus* and *P. pygmaeus*) during their social vocalization in mating period was revealed and is suggested to be a target of further studies.

Impacts of land-use and habitat change on insectivorous bats in rural landscapes, south-eastern Australia

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Throughout the world, increasing use of land for agriculture has been associated with extensive loss and fragmentation of natural habitats and, frequently, the degradation of remaining habitats. This study examines the distribution and abundance of insectivorous bats in south-eastern Australia, to determine the impacts of habitat change and to identify factors influencing the distribution of bat species in rural landscapes. Thirteen species of insectivorous bats were recorded by sampling 184 sites. Two species were rare, but the remaining 11 species were widespread and occurred in all types of remnant wooded vegetation, ranging from large blocks (>200 ha) to small isolated remnants (<5 ha) and scattered trees in cleared farm paddocks. There was no significant difference between remnant types in the relative abundance of bat species, in species richness, or in the composition of bat assemblages. However, sites in open paddocks devoid of trees differed significantly from all types of wooded remnants and had significantly lower levels of bat activity. There was a significant positive correlation between bat activity and the availability of potential arthropod prey. In general, insectivorous bats appear less severely affected than some faunal groups by habitat fragmentation and land-use change. We suggest this is influenced by their highly developed capacity for flight, the spatial scale at which they move, their ability to use multiple landscape elements and to cross open areas to reach these, and their social organisation. However, insectivorous bats are fundamentally dependent on trees for roosting and foraging, and so like all faunal groups are vulnerable to overall habitat loss and ongoing rural tree decline.

New hibernation places of bat species of European importance in Lithuania

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Under the EU Habitats Directive (Council Directive 92/43/EEC of May 1992 on the conservation of natural habitats and wild fauna and flora) the barbastelle bat, *Barbastella barbastellus*, and pond bat, *Myotis dasycneme*, are considered to be mammals of European importance. Both these species are included into the Red Data Book of Lithuania. The barbastelle has the northern edge of its range in Lithuania (Stebbings, 1988; Mitchell-Jones *et al*., 1999). In last decade due to intensive investigations of the bat fauna diversity and distribution, 15 bat species and many new hibernating sites were found in Lithuania. Eight of them are hibernating in Lithuania. One of the biggest colonies of *Myotis dasycneme* and *Barbastella barbastellus* was found in two new bat hibernacula in the south-eastern part of Lithuania: the Silas bunkers and the Paneriai tunnel. The number of barbastelles and pond bats is yearly increasing in these hibernacula where also individuals of *Myotis daubentonii*, *Eptesicus serotinus*, *E. nilssonii* and *Plecotus auritus* do hibernate. The main required conservation measure for the Paneriai tunnel and Silas bunkers is protection against excessive disturbance. For the protection of the high number of *M. dasycneme* and *B. barbastellus* it is necessary to achieve a special theriological conservation status to both hibernacula and to fit all entrances with grilles, which permit the free passage of bats but not people.

The single pulse analysis – a method for quick identification of 'peak frequency bats' (Chiroptera, Vespertilionidae) based on their ultrasound

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Ultrasound calls of nine species of boreal "peak frequency bats" (PF-bats, PF-species) were studied to find an easy method for their identification using a bat detector (Pettersson D240) and sound analysis

software (BatSound, version 1.10). The Sony and Panasonic cassette recorders were exploited to record bat sounds in the field. The study resulted in developing the present method of "single pulse analysis" (SPA) in which either one or only a few pulses (the longest and/or the flattest pulses emitted in relatively open habitat), chosen from a sequence of recorded pulses, are used to identify the species of a flying PF-bat. In SPA the "peak frequency" (PF) of a chosen pulse is the main character used to identify the species, but other characters like "start frequency" and "end frequency" can be used in addition. It is recommended to measure PF along the last 50% of the pulse length (PF50), although the common way of measuring it (along 100% of the pulse length, PF100) is also acceptable. Implementing PF50 reduces variation and, as a result, the PF overlap between species is reduced as well. Implementing SPA includes the following steps: 1) compile a database of bat sounds (DBS) of the study area, 2) develop a key to bat sounds (KBS) using DBS and the characters of ultrasound pulses of each species recorded in relatively open habitat, 3) use the classification of ultrasound pulses of PF-bats to identify the pulse types, 4) identify an unknown PF-bat using the right pulses chosen from its recorded sound, the classification of bat sounds and the KBS of the study area. During the study of bat sounds the so-called "5 kHz rule" was discovered. It appeared that in relatively open habitat the pulses of almost each PF-species have PFs within a strict bandwidth of about 5 kHz.

The types of ultrasound calls of boreal 'peak frequency bats' (Chiroptera, Vespertilionidae)
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During the last decades the study of ultrasound calls of bats has become popular throughout Europe. Using advanced equipment (bat detectors and sound analysis software), bat scientists are constantly improving their knowledge about bat sounds. The main characters of ultrasound in European bats were described during the 1980s and the 1990s. But our understanding of bat sonar is still relatively poor, partly because of the lack of a complete classification of ultrasound pulses. In the present study an attempt is made to present such a classification concerning boreal "peak frequency bats" (bats belonging to the genera *Eptesicus, Pipistrellus, Vespertilio* and *Nyctalus*). An analysis of the sounds of hundreds of flying bats, recorded in northern parts of Europe during 2000–2003, has resulted in the present classification of bat calls including the following call types: 1) "flatting" (long pulses with low start frequency and very narrow bandwidth, appearing flat on sonogram); 2) "commuting" (relatively long pulses with relatively low start frequency and with a typical QCF-part at the end, these are common pulses emitted during ordinary flight in relatively open habitat); 3) "searching" and "piping" (relatively short pulses with high start frequency, large bandwidth and a short QCF-part; these pulses are emitted in relatively closed habitat, often when searching prey; in pipistrelle bats start frequency can be very high and bandwidth extremely large presenting a subtype called "piping"); 4) "approaching" and "swarming" (short FM-pulses with relatively high start frequency and no QCF-part); 5) "buzzing" (a row of very short FM-pulses, a sound made moments before capturing prey); 6) "doubling" (pulses consisting of two partial pulses sometimes attached to each other; these pulses are often emitted during the flight near bridges and other similar obstacles); 7) "social call" (long and undulating pulses, often having several peak frequencies).

On colony and social structure in bats
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Bats found roosting together in the same place at the same time are generally referred to as a colony. Previous authors have defined and categorized social and mating systems in bats according to roosting group (i.e. colony) structure. This approach was taken because more was known of colony structure than social structure, and was a bow to simplicity in systematizing and compartmentalizing what is, in fact, a continuum. In fact, colony composition of most bats is fluid, and bats often roost at different sites with different individuals. Evidence suggests that even solitary bats are social, and several recent studies demonstrate, that colony structure in bats may not map onto their social structure. Thus, if our goal is to understand the social structure of bats, colony composition can be misleading or even irrelevant. These points are illustrated by recent studies of bat colony structure, social structure, and evidence for social interactions; including: 1) fission-fusion social systems in several species of bats, which demonstrate that the conventional perception of a colony from a perspective of social system can be misleading; 2) molecular data that often do not map onto colony structure, suggesting that colony structure and social group structure occur on different scales; 3) information exchange, individual recognition, and communication that occur outside of roost sites but may be important to social structure. This paper is intended to illustrate that studies on social behavior of bats have come far since Dwyer (1971) first posed and refuted the question "Are bats socially conservative?"

The role of bats in conventional agricultural landscapes

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Much of contemporary agricultural production involves large acreages of single crops that experience episodic outbreaks of agricultural pest populations that are difficult to predict. Conventional practice is to suppress eruptions of pest populations with insecticide applications that also impact beneficial insects. An increasingly common alternative is to suppress the development of pest populations by planting genetically engineered, insecticidal, Bt crops. Both pesticides and use of Bt crops result in partial kill of the targeted pest populations allowing for the evolution of pesticide or Bt resistance. We consider the roles of insect-eating bats in this conventional agricultural landscape, and argue that conventional agricultural practices enhance the role of bats by investing the bats with new ecological and evolutionary functions. These functions arise because 1) as highly mobile generalist predators, bats can recruit quickly into the system to exploit pest eruptions in early stages with maximum impact on the growth of pest populations, and 2) because insects that survive pesticides or Bt are those most resistant to the chemicals, harvesting of these survivors by the bats may serve to retard the evolution of resistance. Using Brazilian free-tailed bats, *Tadarida brasiliensis*, as a model system, we describe research to test these ideas using acoustic monitoring of bat feeding activity, analysis of insect DNA in bat feces, and mathematical modeling.

First results of radiotelemetry on *Myotis capaccinii* in Eastern Iberian Peninsula

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Myotis capaccinii is a Mediterranean cave-dwelling species. It is supposed to forage low over water and to trawl for prey on calm water surfaces. The objective of this project is to know the habitat selection pattern and spatial ecology. The study area, in Eastern Iberian Peninsula, comprises the low Xúquer river valley, with some tributary rivers. Rivers are managed for irrigation, being different kind of water reservoirs, an important net of channels and several pools. 20 bats were captured in a cave near to the main river and tagged with radio-transmitters. Bats were followed from 10 to 30 April. More than 8,000 minutes of accumulated foraging activity were obtained from 17 bats. All foraging areas were water surfaces, and as expected there were all calm waters. Bats foraged mainly on rivers, but also in pools and channels. Locations of bat hunting places were mainly comprised in two sectors of the two more important tributary rivers. One of them was 4.6 km long and the other 3.6 km. In these sectors, different bats were located hunting very close one to each other. Some bats showed strong fidelity to hunting places, and only one was located in both rivers. Roost switching happened often.

Bats Conservation Plan in the Valencian Community

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Bats Conservation Plan (LIFE-Natura program) is being carrying out in the Valencian Community (located in Eastern Spain) during 2001–2004. The main objective of this project is to ensure the survival of the present populations of chiropters and minimize the negative factors that affect them. In this area there is a great richness of bat species (22 species have been observed) due to its peculiar climatic conditions. Some of these species are the most endangered in Europe, and their densities in this area are important. Specially, the long-fingered bat, *Myotis capaccinii*, which has in the Valencian Community over half of the species individuals in Western Europe, so the protection of Valencian populations is very important. Another very endangered species in Western Europe, the Mehely's horseshoe bat, *Rhinolophus mehelyi*, is present in this area, and its population is in an advanced process of regression. The scarce Valencian populations require urgent measures that guarantee their recovery. To carry out this general objective, and following recovery plans already stated, these partial objectives are proposed: to ensure the conservation of the most important hides (in this way the protection of 50% of the cave-dwelling species of the Valencian population will be achieved), to increase the small breeding population of forest bats, to ensure the survival of the most threatened chiropters in the area, to complete the necessary information for improving this Conservation Plan, and to make people conscious of the ecological importance of these mammals and the necessity for their protection.

Bearing of neuromorphological traits on reconstruction of chiropteran phylogeny

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Neuromorphological traits constitute the main body of evidence supporting chiropteran diphyly hypothesis. Indeed, early Pettigrew's papers challenging the monophyletic origin of bats have been based almost entirely on the neural traits. However, the heat of the monophyly/diphyly controversy resulted in the comprehensive revision of their heuristic value for phylogenetic reconstruction. Virtually none of the strongest pieces of evidence supporting the diphyletic scenario can withstand the critical analysis in the light of more recent re-investigations. First, the megachiropteran retinotopic organization of the superior colliculus is not primate-like, but follows the general mammalian scheme (Thiele *et al*., 1991). Second, the megachiropteran lamination pattern in the lateral geniculate nucleus is distinctive and differs from that of primates (Kaas and Preuss, 1993). Third, the microchiropteran visual system exhibits regressive features indicative of secondary reductions; a poorly differentiated visual system of insectivorous bats can not therefore be looked upon as a plesiomorphic state (authors' unpublished data). Fourth, gross morphology, cyto- and myeloarchitectonic organization of the spinal cord do not differ significantly between Mega- and Microchiroptera; commonly discussed differences do not refer to any disparate quality or characters with discrete states but to continuous quantitative variables scaled by body size and the degree of the neocortex development (Nìmec *et al*., 2000; authors' unpublished data). Finally, quantitative brain characters, when analyzed within an appropriate statistical framework, do support the monophyletic origin of bats (Lapointe *et al*., 1999).

A LIFE-Nature project for the conservation of three cave-dwelling bats in southern France

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Over 33 French bat species, 31 are present in the most southern part of the country. This shows the great richness of bat species of this area. However, as in the other parts of the world, a spectacular decline of the bat populations is observed. Three cave-dwelling bats are particularly threatened: the

Mediterranean horseshoe bat, *Rhinolophus euryale*, the long-fingered bat, *Myotis capaccinii*, and the Schreiber's bat, *Miniopterus schreibersii*, whose distribution is roughly restricted in France to the southern part of the country. Several causes for this decline are identified: the disturbance of populations caused by human frequentation of bat roosts, the overall deterioration of bat natural habitats, the lack of a basic knowledge of bat ecological requirements, the lack of education of the human population. A LIFE-Nature project has begun on April 1st 2004 (until 30 April 2008) in order to restore, at a favorable conservation status, French populations of this three cave-dwelling bats (the other syntopic bat species will all benefit from the planned actions). This project is co-ordinated by the French Mammal Society (SFEPM) with the participation of 12 partners (Nature protection associations mainly) and 16 co-financiers, plus the European Commission. It benefices of a global budget of 1.2 millions euros. It is based on a network of 13 Sites of Community Importance (SICp), supporting 26 bat roosts. Three main actions are scheduled: the physical and/or legal protection of maternity, hibernation or transit roosts on the 13 SICp; the study of the diet and habitat use of the 3 species concerned by the project; the sensibilization and the involvement of public, local people and users of underground habitats in the conservation of bats.

Habitat preferences and resource partitioning in sympatric pipistrelle bats

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The recent separation of the commonest British bat, the pipistrelle, into *Pipistrellus pipistrellus* (common or bandit pipistrelle) and *P. pygmaeus* (soprano pipistrelle), which are sympatric in Scotland, raises the question as to how these two species partition resources in time and space. This study addresses habitat preferences of *P. pipistrellus* and *P. pygmaeus* using radio telemetry. Compositional analysis was used to investigate habitat selection and rank habitats in order of preference, and revealed that *P. pygmaeus* forages selectively over water and within adjacent riparian woodland, areas typically associated with high insect density. *Pipistrellus pipistrellus* foraged predominantly within woodland edge, typically along small discrete tree lines bordering a wide range of habitat types, and also used riparian woodland disproportionately to its availability. *Pipistrellus pipistrellus* foraged over greater distances and foraging ranges were on average twice as large as those of *P. pygmaeus. Pipistrellus pipistrellus* also visited more foraging areas per night. There was almost complete spatial segregation between the two species suggesting that there is no current competition between them. It is possible, however, that past competition may have led to the exclusion of *P. pipistrellus* from the apparently higher quality habitat found within the colony home range of *P. pygmaeus*.

Changes in flight kinematics with increasing flight speed in a nectar-feeding bat, *Glossophaga soricina*

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In terrestrial locomotion gait change occurs in discrete steps, from walking to trot to gallop. Similar gait changes have been observed in some bird and bat species during flight at different speeds. We studied how the flight kinematics changes with increasing flight speeds in a nectar-feeding bat, *Glossophaga soricina*. Bats were filmed at 200 frames/s when they were flying at speeds varying from 1 to 9 m/s. The bats flew in a 35 m long flight tunnel and they triggered the camera only at pre-selected flight speeds. Different flight speeds were obtained by varying the length of the flight tunnel. The results show that this bat species changes flight gaits gradually rather than in discrete steps as speed increases.

Factors influencing survival and population viability in long-tailed bats, *Chalinolobus tuberculatus*: results of a long term mark-recapture study from New Zealand

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The survival rate of a species is one of the key parameters for determining the long-term viability of populations. Analysis of the factors influencing survival and population viability is therefore an important tool for improving management of populations of threatened species. The long-tailed bat, *Chalinolobus tuberculatus*, is classed as vulnerable. Its survival in temperate beech (*Nothofagus*) forest, Eglinton Valley, Fiordland, New Zealand was estimated using mark-recapture data from 1993-2003 using Program MARK. A total of 5,286 captures, representing 1,026 individuals was recorded. Annual survival rates in the best-fit model ranged from 0.29 to 0.83 but varied significantly among three social groups, years with high and low densities of predators, with sex and age and with average winter temperature. Overall, females had a higher survival rate compared to males; and adults had higher survival compared to juveniles. Survival of all bats was lower in years when numbers of introduced mammalian predators were high and when winter temperature was warmer than average. High numbers of introduced predators occurred during three of the ten years studied. At this rate, a preliminary population viability analysis using a projection matrix on the overall adult female population, showed an average 5% decline per year ($\lambda = 0.95$). Increased predator control targeting years when predator levels are high is required in order to halt the decline of this bat species.

Bats as a source for generation of local radioactive foci

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The longstanding deposits of bat faeces, containing high concentrations of radionuclides were described in 1993 in the woody buildings situated on the bank of the lake in the surroundings of "Mayak" Production Association. Further studies indicated that this and other local radioactive foci were associated with the maternal colonies of two species of bats: *Myotis dasycneme* and *Eptesicus nilssonii*. Concentration of ^{90}Sr in tissues and faeces of *M. dasycneme* is statistically higher than in *E. nilssonii*. ^{137}Cs and ^{106}Ru were also found in tissues and faeces of these bats. Analysis of trophic links indicated that both species feed mainly on Chironomidae, whose larvae develop in the reservoirs with highly radioactive technologic water. For *E. nilssonii* the bulk of the diet consisted of insects developing in the terrestrial communities. Analysis of the insects caught with the light traps had shown that concentration of radionuclides in "aquatic-developing" insects was higher than in "terrestrial" species. Thus the difference between *M. dasycneme* and *E. nilssonii* in radiation power and radionuclides accumulation results from the specific features of the species trophic niches: while *M. dasycneme* hunt close to the open water and consume mainly the insects developing in the water, *E. nilssonii* can "dissolve" their diet with the "clean" insects. We suppose that considered radioactive foci could be generated as follows: the radionuclides presented in the technological waters accumulate in larvae developing in the reservoirs of "Mayak" PA. These radionuclides are moved with imago out of the aquatic communities and consumption of these insects by bats results in accumulation of radioactive elements in long-standing deposits of bats' faeces in the roosts.

Foraging flexibility and response to prey mating calls in the frog-eating bat, *Trachops cirrhosus*

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The fringe-lipped bat, *Trachops cirrhosus* (Phyllostomidae), feeds on frogs, and uses frog mating calls to detect, identify, and locate its prey. Our studies investigate the role of localization ability on acoustic preferences, and the role of learning on foraging success. *Trachops cirrhosus* feed abundantly on túngara frogs, and prefer complex túngara frog calls to simple ones. Complex túngara frog calls have components that are short in duration, have fast rise and fall times, and a rich harmonic structure, factors that should maximize binaural comparisons and increase localizability. We tested the hypothesis that *T. cirrhosus* prefer complex calls to simple ones because they are easier to localize. Additionally, we tested the foraging flexibility of this species via learning. On the basis of acoustic cues alone, *T. cirrhosus* is able to discriminate between poisonous and palatable prey species. Given the foraging plasticity of this species, we hypothesized that the strong associations between acoustic stimulus and prey quality are largely learned and are flexible. We tested this flexibility in the most extreme scenario of reversing the bat's natural preference for túngara frog (*Physalaemus pustulosus*) calls and natural aversion to marine toad (*Bufo marinus*) calls. We found that rather than being fixed, this bat's associations between prey cue and prey quality are highly flexible. These studies show that the predatory bat, *T. cirrhosus*, has a heretofore undescribed ability to rapidly reverse its evaluations of what cues signal palatability and what signal toxicity.

Ecology and conservation of *Myotis capaccinii* in Dadia National Park, Greece

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The Dadia National Park in north-eastern Greece is principally pine and oak forest over low but rugged hills and valleys. On the boundary between Europe and Anatolia, it is an area of outstanding biodiversity. Famous for its raptors, it also has a rich bat fauna. In the first year of this project we increased the number of recorded species from 17 to 24: all five European *Rhinolophus* species, *Tadarida teniotis* and 18 Vespertilionidae. The list includes five IUCN "red list" species: *Rhinolophus euryale*, *R. mehelyi*, *R. hipposideros*, *Myotis emarginatus* and *M. capaccinii*. The main aim of the study is to determine the roosting habits, population structure and foraging behaviour of *M. capaccinii*. Preliminary results indicate a large breeding population that forms nursery colonies in a small number of disused mines and natural caves in and just outside the Park. These underground sites are also used as transient roosts by bats traveling between hibernation and breeding sites, some located in Bulgaria. Ringing and radiotelemetry indicate that the bats forage over a wide area, commuting long distances (up to 30 km) to forage over seasonal rivers. There is significant interchange between roosts up to 38 km apart. Most bats migrate out of the Park to hibernate, which might be related to unsuitable microclimatic conditions inside the roost sites. Additional aims are to build an echolocation call library for the Park's bats and to establish a long-term bat monitoring programme in collaboration with WWF.

Homing behaviour after translocation: do bats have a magnetic sense?

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The forced translocation of bats from their roost or home range can occur for a number of different reasons. However, almost invariably the bats attempt to return and their homing ability has been recognized as a factor in failed translocations. In New Zealand, predator-free mainland and offshore islands are frequently used as refuges for endangered species, and the translocation of threatened bat populations to these islands is planned in the near future. Developing a translocation protocol that incorporates an understanding the homing mechanisms and abilities of bats will help maximize success. In this talk I present results from an experiment designed to investigate if long-tailed bats, *Chalinolobus tuberculatus*, (Vespertilionidae) are capable of returning to a predefined home location after forced translocation to areas both within and outside their known home ranges. We also studied the initial release behaviour of the translocated bats to discover if they were orienting to the earth's magnetic field (in manner similar to that displayed by homing pigeons) to determine their position (the map step) before homing (the compass step). All bats returned home within several days of being translocated, including those moved outside their home range. Confounding behaviours such as feeding and resting made it difficult to determine the initial orientation behavior. However, at least one bat demonstrated behaviour consistent with those displayed by homing pigeons when orienting to the earth's magnetic field.

Globally endangered *Craseonycteris thonglongyai* in Myanmar

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The bumblebee bat, *Craseonycteris thonglongyai*, is considered by IUCN as globally threatened and until recently was only known from the area of the River Kwai, in Thailand, where its population was estimated to be around 2,300 individuals. However, it was recently found in Mon State (Myanmar) and the objective of our project was to survey and characterize the species in the region. Our survey was carried out in October and November 2002 and covered large karst areas with numerous caves in the states of Mon and Kayin. We found *C. thonglongyai* in nine caves, and estimate that its regional population is about 1500 individuals. New locations extended the known range of the species about 100 km to the north. The analysis of calls showed that they are clearly distinct from those emitted by animals of the Thai population. Molecular phylogenetic analysis suggests that the Burmese population forms a monophyletic clade, separated from the Thai animals by just three substitutions. The Burmese individuals were slightly heavier, but they were otherwise morphologically similar to those of Thailand. The population of *C. thonglongyai* in Myanmar has great conservation value. Major threats to its populations and key roost sites have now been identified.

Local summer community of bats in the south Middle Urals

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During the spring, summer and autumn periods of 2002–2003 the author examined a local seasonal community of bats that occupied a plot of about 3.4 km^2 possessing different habitats. The plot is situated just at the boundary of two vegetation zones: the south taiga and pine-and-birch forest-steppe forests. Variety of habitats and ecological conditions appear favorable for typical forest species of bats, namely: *Myotis dasycneme*, *M. daubentonii*, *M. brandtii*, *Eptesicus nilssonii*, *Plecotus auritus*, and *Pipistrellus nathusii.* The last one is a migrating form in the Middle Urals. One more migrating species, *Vespertilio murinus*, usually preferring open lands, has been registered in the region at study. Only adult females and cubs of the migrating species were marked, adult males missed. *M. daubentonii* and *V. murinus* were the most usual and abundant in the region. The highest species diversity and the highest animal numbers were marked in the antropogenic landscape, in the floodplain and in by-floodplain pine-and-birch forests. During the warm periods, the bat community showed fluctuations in the species composition and animal numbers. Both characteristics showed the highest values during the period when the cubs become independent. During the whole warm periods, 4 bat species inhabited the region: *M. dasycneme*, *M. daubentonii*, *M. brandtii*, and *E. nilssonii. Vespertilio murinus* was only recorded in summer months, probably during the breeding periods. *P. nathusii* was observed for short intervals only, probably during the migration of females and yearlings, leaving their summer habitats. Thus, during the spring, summer, and autumn months, the local bat community demonstrated dynamics of the species composition and animal numbers.

Pattern recognition in early cranial ontogeny of the common vampire bat, *Desmodus rotundus* (E. Geoffroy, 1810), and the lesser bulldog bat, *Noctilio albiventris* (Desmarest, 1818), by X-ray microradiography and phase contrast imaging

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Ontogenetic information has been used to formulate hypotheses of homology through comparative studies of ontogenetic sequence and the analysis of interspecific patters of variability. A possible limitation in this approach is usually imposed by the difficulty in the observation of structures in early stages of development, usually performed on cleared and stained specimens. In this study we examine developmental pattern of cranial characters formation in preborn individuals of vampire bats *Desmodus rotundus* and lesser bulldog bat *Noctilio albiventris.* We used microradiography and phase contrast radiography, as a first step to understand how the skull characters appear in the primordial stage of embryology. These techniques of non-destructive testing have been used to obtain images with greater resolution. The sample used in this study was collected in central and eastern Brazil, fixed in formaldehyde, and kept in alcohol 70%. The images show the early stages of development of *D. rotundus*, including the formation of the forearm and the orbital region as well as the post-anterior axis in the embryo. In a subsequent stage of development several cranial structures can be diagnosed. It was possible to identify an advanced stage of development of the mandible with respect to other cranial structures. The microradiography in *N. albiventris* also revealed the formation of braincase and rostrum in early pre-born embryos. In the rostral region the nasal bones and mandible can be observed. These techniques can be useful for studying rare collection specimens and in ontogenetic pattern recognition. Microradiography and phase contrast imaging improved quality in the analysis of morphological details and permitted the identification of anatomical landmarks that are useful in comparative studies and are still unknown in both pre born bats species. We are grateful for the financial support of LNLS (project XRD2 1692) and PRONEX/CNPq for this project. LMP, RTL and CG is partially supported by CNPq and CAPES supports FET.

Bat pollination in a West African rain forest community

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The aim of this study was to investigate the interaction between bats and flowers at the community level in a rain forest in Ivory Coast, during twelve calendar months. Bats were caught in five permanent plots between 2001 and 2004. Presence of pollen in the fur and feces of bats were used as indirect measures of flower visitation. Flowering phenology was studied for five bat visited tree species in the area and their density were estimated by line and square transect samplings. *Megaloglossus woermanni* and *Myonycteris torquata* are the only of seven regularly captured fruit bat species that, judged from pollen presence, utilize nectar as a food source in this area. Preliminary results show that six tree species, representing four families and four genera, are the major food source for *M. woermanni*. In addition, two unidentified pollen species were found on two occasions. A majority of *M. torquata* carried pollen from three of the identified species, which suggest they are highly attractive to this bat species. The phenological data shows that the flowering periods are sequential in four of the plant species, while the fifth have a steady state flowering all year round. Recapture data suggest that *M. woermanni* has a fairly limited foraging range and pollen findings, phenology and tree density data supports a stationary strategy. In *M. torquata* findings of pollen from plant species not occurring or flowering locally indicate that this species has a larger foraging range.

Flight and echolocation behaviour of Myotis nattereri foraging close to vegetation

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Natterer's bats, *Myotis nattereri,* are specialized in finding prey in the vicinity of vegetation. We recorded the flight and echolocation behaviour of five bats that were trained to detect and catch prey presented at different distances in front of semi-natural hedges in the lab. The flight behaviour differed depending on the distance between prey and background. With decreasing distance between prey and hedge the number of unsuccessful search flights increased thus indicating that detection is more difficult when the prey is placed closer to the hedge. Nevertheless, the bats were capable of catching prey that was positioned only a few centimetres away from the next branches. Additionally, we describe the echolocation behaviour and especially the scanning behaviour of bats while catching prey positioned at different distances to the semi-natural hedge.

Roost utilization of an urban park by the greater noctule, *Nyctalus lasiopterus* in Spain

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Day roosts are vital resources in bats life strategies. We are studying the selection and use of day shelters in a tree-dweller species, the greater noctule, *Nyctalus lasiopterus*, in a situation of relatively high availability of shelters, but that are very concentrated in space. María Luisa's city Park is a 20 ha urban park located in the city of Sevilla (Spain). It is the only forested area with abundant mature trees in several tens of kilometers around. Here finds its shelter an important population of greater noctule, comprising probably more than 200 individuals. Foraging areas for these bats are generally about 20 km distant from the roosts, although sometimes bats can forage as far as 50 km or even more. The bats were netted, banded and marked with transponders and in some cases also with radio-transmitters. These techniques provided us with two types of information. First, monitoring the radio-tagged bats has allowed us determine which trees they use and how they shift between shelters. Second, we were able to follow activity patterns (every marked bat entering or leaving the roost) in some specific tree shelters where we have installed automatic transponder-reading devices. Our results suggest that there are at least three subpopulations of greater noctules in the María Luisa Park exhibiting territorial behavior. Members of each group shift tree-shelters frequently but use only those located in their territory. We could not detect differences between subgroups of bats, though, in their foraging behavior. It seems that foraging areas are visited indiscriminately by the three subpopulations.

Changes in bat fauna in middle and lower holocene: ^{14}C AMS dating of thanatocenoses from Kraków-Czestochowa Upland (Poland)

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Thirteen thanatocenoses were separated from 17 samples of osteological material from 12 caves located in Krakow-Czestochowa Upland (South Poland). The bat bones from there thanatocenoses were dated by ^{14}C AMS, and 13 dates between 6,725–820 years ^{14}C BP were determined. Two groups of bat species and two groups thanatocenoses were established for atlantic and subboreal period: 1) mediterranean species with higher frequency in the atlantic period: *Rhinolophus hipposideros* and *Myotis emarginatus*; 2) *Myotis daubentonii, Plecotus auritus, Myotis dasycneme* with higher frequency from humid and cold periods; 3) *Myotis nattereri* dominant thanatocenoses from the Holocene climatic optimum (atlantic); 4) *Myotis bechsteinii* dominant thanatocenoses from subboreal period – maximal frequency of this bat species correlated with increased *Fagus* and *Carpinus* content in forests. The decrease in frequency of *M. bechsteinii* was probably caused by a disease and independent of human activities. *Myotis myotis* was present in fossils from atlantic period. The fossils from a breeding colony of the Nietoperzowa Cave (820 ± 25 year ^{14}C BP) indicate that reproduction of this species was taking place in the north from Carpathian Mts. before human settlement. The presence of large association of *Pipistrellus pipistrellus* s.l. in caves in subatlantic period indicates the independence of climate as well as human influence on the ecosystem. The reconstruction results for atlantic and subboreal periods show that bat fauna changes correlate with climate and vegetation. The human influence on the ecosystem seems to be minimal. Comparison between paleozoological and ^{14}C dating revealed the significant differences in the thanatocenoses age estimation.

Differential ectoparasitic mite *Spinturnix myoti* in breeding and non-breeding colonies of *Myotis myotis* and *Myotis blythii* in Central Europe

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Two breeding colonies of *Myotis myotis* in Kraków-Wielun Upland were investigated. One was located in a church attic in Klobuck (t = 25.5°C) and the second in 30 km distance, in the Studnisko Cave (t = 12°C). Bats were captured from the colonies between 30 July and 2 August. Body Condition Index was used as a measure of condition. Parasites (*Spinturnix myoti* — Mesostigmata, Spinturnicidae) were collected from wing and tail membranes of *M. myotis*. Additional research observations were carried out in Romania: in breeding colony located in cave (2002) and in breeding colonies in caves and church attics (2003), and in summer colony in cave (without mating). There were no differences in parasite numbers among the checked season in the church attic. However, we noted the differences among age-gender groups. For the cave there were differences among seasons, as well as age-gender categories. Significant differences in parasite number were observed for attics and caves (independent of the country). We noted the differences between the breeding colony in the cave and the summer (non-breeding) colony in the cave. We observed the correlation between condition (BCI) of *M. myotis* and *M. blythii*, and *S. myoti* numbers. For >50 number of mites per bats the correlation appeared to be in agreement with the "vulnerable host" strategy. The number of *S. myoti* in breeding colonies in attics and summer colonies in caves is significantly lower than in breeding colonies in caves. This disproportion is not explained by any hypothesis presented so far and is now thoroughly investigated by the authors.

Swarming behaviour of temperate bat species in southern Poland

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Swarming behaviour of temperate bat species was studied in southern Poland in 2000–2004 in 6 underground sites located in lowland, upland and in mountains. Analysis was carried out for the 8 most common species: *Barbastella barbastellus, Plecotus auritus*, *Myotis daubentonii*, *M. nattereri*, *M. emarginatus*, *M. bechsteinii*, *M. brandtii* and *Eptesicus serotinus. Barbastella barbastellus*, *P. auritus* and *M. nattereri* in SW Poland, and *M. nattereri*, *M. daubentonii* and *M. emarginatus* in Central-Southern Poland were found to be dominant swarming species at investigated sites. Furthermore, we noted higher diversity of bat species composition in the caves of Central-Southern Poland. The activity of bats in caves and mines depended on thermal seasons and was noted in spring and autumn. We observed differences in time, length and distribution of activity as well as sex proportion, between species and different years. All investigated species showed one peak of activity in spring, which is associated with emerging after hibernation. Only *P. auritus* was observed to swarm in spring and autumn. The autumn peak of swarming was characterized with one- or multimodal distribution with various duration among species, only *P. auritus* and *B. barbastellus* distributions were similar. In all species the proportion of males was higher than females. Social behaviour characteristic for swarming (vocalization, chasing and copulations) were observed in five bat species: *B. barbastellus*, *P. auritus*, *M. daubentonii*, *M. nattereri* and *M.*

emarginatus. In order to find specific models we correlated swarming behaviour with the biological and ecological features of each species.

Use of two forest types by bats in Deeside, Scotland

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Forest types studied were mixed coniferous forest plantations and natural-growth birchwood in the Dee River Valley. Both of these woodlands consist of different habitats like forest edge-meadow, forest edge-waterbodies, as well as dense woodland. Bat species encountered were *Pipistrellus pipistrellus, Pipistrellus pygmaeus* and *Myotis* spp. Research was carried out June-August 2003. Bat species encountered on 2.5 km line transects were identified and counted using time expansion ultrasound detectors, and general bat activity was recorded throughout the hours of darkness using automatic stations. More time was spent by both pipistrelle species over the edges of the waterbodies than over the meadow. *Myotis* species were recorded mostly over the river. In conifer forest, dense woodland habitat was much less preferred than edge habitats. In birchwood this difference in habitat use was much smaller. This disparity was probably the result of a difference in structure between natural-growth birch stands, where the trees are well spaced, and conifer plantations, where they are closer together.

Bats of the Atlantic archipelagos of Azores and Madeira: status and habitat use

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Azores and Madeira, volcanic archipelagos located in the North Atlantic Ocean, make up much of the small insular biogeographic region of Macaronesia. Mostly due to their isolation these islands are ecologically unique, but many of their natural values have been destroyed or are presently threatened. Bats are the only terrestrial mammals native to both archipelagos. Bats were surveyed on almost all the major islands using bat detectors and roost searches. Two species were observed in the Azores: the endemic *Nyctalus azoreum*, and *Pipistrellus* sp. (The taxonomic status of the *Azorean* populations of *Pipistrellus* is not entirely clear). *Nyctalus azoreum* is present on 7 of the 9 islands and is fairly common on most of them, whereas *Pipistrellus* sp. is quite rare on the three small islands where it is present. They only coexist on the island of Santa Maria. Three species were recorded in Madeira: *Pipistrellus maderensis*, endemic to Macaronesia, *Nyctalus leisleri verrucosus*, an endemic subspecies, and *Plecotus austriacus*. On the main island (Madeira) the two first species were fairly common but the situation of *P. austriacus* was less clear. Only *P. maderensis* was recorded in the island of Porto Santo, where it is quite rare. Even the most common of these species are of conservation concern due to the relatively small size of their islands populations, isolated in a small geographic range. Some islands have very small populations that are highly threatened. Roost destruction, the expansion of exotic vegetation, inadequate use of pesticides, and changes in public illumination systems are the most obvious threats to bats.

Slaughter of grazers due to foot and mouth disease confirms the importance of *Aphodius* dung beetles to the greater horseshoe bat, *Rhinolophus ferrumequinum*

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Jones (1990) showed that these bats are selective feeders, consuming a variety of prey through the summer months. Ransome (1996, 1997) confirmed that the range of prey consumed was the same at maternity roosts across the UK. Ransome (1996) classified prey into two groups; key prey that are preferred if available, and secondary prey that are only eaten if key prey are either unavailable or unprofitable. From late July the small dung beetle, *Aphodius rufipes,* formed an important key prey component of colony diets. Young bats fed primarily on *Aphodius* beetles when they first started to forage at age 30 days, whilst their mothers mostly ate moths, their key prey at that time. In February 2001 a severe outbreak of foot and mouth disease (FMD) affected parts of the UK, including some areas occupied by greater horseshoe bat colonies. Over 4 million grazers, mostly sheep, were culled as a control measure, with some restocking beginning in spring 2002. English Nature commissioned this study to discover the impact of FMD slaughter upon two maternity roosts; one within a FMD slaughter area in the Forest of Dean, the other just outside. We used dropping collections made in years before and after the slaughter to characterise the diets at the two sites, and continued our juvenile growth and population studies at each roost through the FMD affected period. Prior to FMD slaughter, summer diets at the two roosts were almost identical in two out of three years sampled. In the third summer Woodchester bats ate more *Aphodius* beetles than Dean Hall bats, and fewer moths. Only the latter colony was directly affected by FMD slaughter in 2001. In the summer of 2001, *Aphodius* consumption fell significantly at both roosts, but much more at Dean Hall. A recovery to former levels occurred in 2002, but only at Woodchester. Bats at both roosts switched to secondary prey, such as small summer chafers and tipulids in both the summers of 2001 and 2002. Amounts of prey consumed per bat fell at both roosts, but much more at Dean Hall. By summer 2002 forearm growth of female juveniles at Dean Hall had been significantly affected, with increased roost mortality over pre FMD summers. Woodchester bats were also affected, showing reduced body condition and survival rates of female juveniles after FMD slaughter. Similar data were not available for Dean Hall bats. Data suggest that the switch from key to secondary prey carries a consumption and survival penalty, and may have driven the high prey selectivity shown by this species. This study confirms the value of environmental prescriptions made for this endangered species by Ransome (1996). Both colonies had shown an encouraging increase in their populations prior to FMD slaughter. Reduced survival rates may limit further rises unless stocking levels are restored.

Bat conservation and big dams: the case study of Alqueva and Pedrógão dams

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Alqueva dam, in southern Portugal, was recently completed and its reservoir is now almost completely full. Covering a surface of 250 km^2 this is the largest reservoir in Europe and flooded large areas of valuable habitats, including important extensions of riparian habitats. In the year 2000, prior to the beginning of flooding and deforestation, we conducted a study of bats to determine their distribution and foraging habitat use, and to locate important roosts. In 2003 in order to monitor the impact of the project on the bats, a similar study on bat foraging habitats was conducted and important roosts were visited. As expected, overall bat activity in the now flooded areas is very low, so the project resulted in a substantial reduction in the area available to bats. In the area surrounding the reservoir bat activity went up, however habitat use remain the same. The study area, which included not only the site of the reservoir but also the adjacent region, loss 22% of the known roosts, affecting five bat species of which three are of conservation concern. The numbers of species and individuals in the remaining monitored roosts did not change. A high number of roosts of tree and rock-dwelling bats were certainly destroyed, especially in areas of woodland and cliffs, but due to methodological constraints they were not located and monitored. Further damage to the regional populations of bats can be avoided if roosts are protected and if their foraging habitat needs are incorporated in the management of the area surrounding the dam and of the newly irrigated farmland.

Distributional status of *Pipistrellus pipistrellus* (Schreber, 1774) and *P. pygmaeus* (Leach, 1825) in the Czech Republic: results of mapping

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New cryptic species of common pipistrelles, *P. pipistrellus* sensu stricto and *P. pygmaeus* can be reliably identified in the field by bat-detectors (later by PC analyses) and on a basis of mtDNA analysis (cyt b gene) of a tissue target of patagium acquired from netted bats. In the area of the Czech Republic *P. pipistrellus* sensu lato was considered common bat species distributed in the majority of the state area. We summarized all former data about occurrence of all common pipistrelles at first, especially sites of nursery colonies. All sites we included to the grid map of the Czech Republic divided into 695 quadrates unified to all faunistic researches in the Czech Republic. In total, a database comprised 916 records of *P. pipistrellus* s. l. in 146 quadrates (21% of the territory under study). Since 2002 the research project has been started to map the distribution of both pipistrelles separately using mainly bat-detectors. The line transects were conducted in suitable habitats of each mapping square visited. Hitherto, 296 sites of *P. pipistrellus* s. str. in 103 mapping quadrates (15%) and 135 sites of *P. pygmaeus* in 40 quadrates (6%) have been found. While *P. pipistrellus* s. str. occurred almost in the whole territory except the high mountain elevation, the range of *P. pygmaeus* was considerably lesser and the main area of its distribution is that in southern Moravia and southern Bohemia. *Pipistrellus pygmaeus* especially prefers floodplain forests and other wetlands in the aluvium of Morava, Dyje and Svratka rivers and a pond landscape in the Tøeboò and Èeské Budìjovice basins where it prevails sympatric *P. pipistrellus* s. str. Most records of *P. pygmaeus* come from low altitudes (150–200 m a.s.l., max. 450 m a.s.l.) whereas *P. pipistrellus* s.str. has been recorded up to 862 m a.s.l. and it does not avoid wooded highlands or human settlements contrary to former species. *Pipistrellus pipistrellus* s.str. seems to be allopatric in the mountain northern part of the Czech Republic.

Fission-fusion in *Tadarida australis*

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Some mammalian species are known to alternatively split into subgroups and to fuse again to stable social groups (fission-fusion). This phenomenon is poorly understood but is often linked to reproductive status, resource availability, predation pressure and social relationships. In microbats, roost switching has been found to relate to the type of roost occupied. Bats roosting in permanent structures (caves, mines, buildings) are faithful to fewer, permanent roosts. In contrast, bats roosting in smaller roosts (tree hollows, crevices, under bark, etc) tend to switch roosts frequently. The present study examined the roosting behaviour of *Tadarida australis*. In order to investigate whether this hollow-dependent species conforms to the fission-fusion model, a total of 19 individuals were radio-tracked to their day roosts. Capturing took place at a communal roost. All bats were faithful to their roost sites, only rarely switching between the communal roost and one (seldom two or three) more solitary roost sites. Individuals visited the communal colony at night even if they were not roosting there during the day. These data suggest that *T. australis* uses fusion-fission to maintain long-term social relationships.

Bats and the larger landscape

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The National Trust (NT) is a charity that cares for natural and built heritage in England, Wales and Northern Ireland. It owns and manages parklands, farms, woodlands, gardens, uplands and coastline totalling 250,000 ha. Of 48 Special Areas of Conservation (under the EU Habitats Directive) for bats in the UK, 19 are on NT land. All 17 UK bat species occur on NT land, and all but two are known to breed.

The Trust has a significant proportion of the population of rarer species on its land, such as *Barbastella barbastellus*, *Rhinolophus ferrumequinum*, *R. hipposideros* and *Plecotus austriacus.* Radio-tracking studies of these species have shown that despite ownership of large tracts of land around the roosts, individual bats frequently foraged well outside the NT boundaries. For example, *Rhinolophus* and *Barbastella* radio-tracked in south-west England and Wales foraged many kilometres from their roosts, sometimes commuting over open landscapes with no obvious natural features to guide flight lines. Thus, even for the apparently non-migratory bat species in the UK their conservation management is only realistic at the landscape scale and in partnership with other major landowners. To address this the NT has embarked on a partnership in Dorset where seven major organisations with land have set up a project group to produce a management plan for *R. ferrumequinum* across a large land area to protect its roosts and flight lines and enhance its foraging.

Murinodonty as the special type of lower molars of Chiroptera

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Until now only two extreme odontological types of lower molars of Chiroptera have been known: nyctalodontal and myotodontal. Nyctalodonty is characterized by the position of postcristide, which join together hypoconide and hypoconulide without reaching entoconide; myotodonty is characterized by the position of postcristide, which join hypoconide and entoconide leaving hypoconulide in the distant isolation. Nyctalodonty is the ancestral condition of crowns of lower molars (Menu 1985). Beside these extreme variants with *Lasionycteris octivagans* could be seen the intermediate state of lower molars; submyotodonty (Legendre 1984), which is characterized by the dichotomy of postcristide and the skew of the larger branch towards entoconide. However the detailed odontology research of the two species of *Murina*, distributed on the territory of Russia (*Murina leucogaster* and *M. ussuriensis*), have revealed one more odontological type, which differs from all types described previously. The crown structure of lower molar of *Murina* is typical for Chiroptera: there is a three-cuspid talonid. But the distinct hypoconulid is situated close to the entoconid and joined to its top by clear crest. So all three cuspids of talonid are connected by the crests one after another and formed circle around the talonid basin (postfosside). We call this state as murinodontal. Murinodonty is characterized by such a position of talonid crests (including postcristide), that they join hypoconide and entoconide through hypoconulide. Apparently murinodonty, along with myotodonty, derived from nyctalodontal odontological type.

Breeding behaviour and its implications for sociality in temperate bats

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Breeding behaviour can have important consequences for levels of kinship and kin-based sociality in animal populations. In many temperate bat species, the sexes are segregated for much of the year but form seasonal mating groups. A lack of clear compositional stability of these groups both within and across mating seasons has led to suggestions that such mating behaviour is probably promiscuous or random. Here we describe how a 10-year study of the temperate greater horseshoe bat, *Rhinolophus ferrumequinum*, is providing evidence that breeding in this species is far from promiscuous, and could have important implications for the maintenance of colony ties among females. We screened 452 bats at our study colony at ~19 microsatellite loci, including >98% (n = 348) of offspring born 1993–2002. Paternity was assigned to 232 offspring, and was shared among 58 males. Male reproductive skew was significant, with three bats together siring >20% of all offspring born. Despite exhibiting sexual segregation for most of the year, 60% of females bred with the same male in 2–5 years, producing full-sibs. In addition, we observed female kin mating with the same male in 20 cases. Although this occasionally involved descendant female kin, incest was nearly ways avoided due to females switching mates across years. Male skew, mate fidelity and intra-lineage polygyny all contribute to higher kinship levels within the maternity colony than would occur through promiscuous mating. Our results, which may apply to other bat species, illustrate how genetic studies can reveal complex breeding behaviours that may promote colony cohesiveness.

Do bats and birds select similar tree-holes during the breeding season?
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In order to determine whether bats and birds select similar cavities, tree species, diameter at breast height (DBH), and height of hole above ground level were compared. Data on birds were obtained from relevant literature, while those concerning bats were collected using radiotelemetry (1998–2002). Bats most often (over 80% of localized roost trees) utilised oaks (*Quercus robur*), ashes (*Fraxinus excelsior*), rarely alders (*Alnus glutinosa*), and accidentally limes (*Tilia cordata*), aspen (*Populus tremula*), pines (*Pinus silvestris*), maples (*Acer platanoides*), and hornbeams (*Carpinus betulus*). Of the 12 bird species investigated, alders were commonly used by 10 species, while hornbeam by 8. Oaks were also frequently used by 2 bird species, while maples, poplars, and spruces by only 1 species of bird. Trees utilised by bats normally had a DBH of over 65 cm, while DBH of trees occupied by birds had less than 65 cm. Cavities of bats were also localized higher above ground level (average 18–19 m) than birds (average 6–17 m). The results of this study indicate that bats and birds in Białowieża Forest use different trees and cavities as breeding sites. Estimated availability of suitable trees for bats is smaller than for birds, therefore it seems that bats are more selective when choosing cavities to roost in.

A molecular appraisal of the *Myotis myotis – blythii – punicus* species complex: the good, the bad and the ugly!
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Recently separated populations or species present a real challenge for the taxonomists who wish to understand the evolution of speciation, mainly because lineages are not expected to segregate instantly into reciprocally monophyletic assemblages. Thus, ancestral polymorphism, incomplete lineage sorting, or episodes of hybridization may complicate the outcomes of phylogenetic reconstructions in such situations. In an attempt to define the number of major evolutionary units in the species complex of the large *Myotis* from the Western Palaearctic, we sampled and sequenced a mitochondrial DNA marker for 130 individuals. Surprisingly, this large data set segregated into two very distinct clades: the first one corresponded to a long-suspected new species, *M. punicus*, from North Africa (see Castella *et al*., 2000), while the other included a mixture of all European and Middle-eastern *M. myotis* and *M. blythii*. This suggests the existence of only one major evolutionary unit within large *Myotis* in continental Europe, a result that contradicts previous morphological, genetical and ecological data. In order to investigate further the existence of a single evolutionary unit in Europe, we sampled 80 individuals each of *M. myotis* and *M. blythii* in two areas of strict sympatry and analysed them with several nuclear DNA markers. 98% of the genotypes were assigned correctly to either species, with no evidence of hybridization. We used these apparently contradictory results from both classes of DNA markers to propose a scenario for the evolution of this interesting species complex.

Some faunistical aspects of the ectoparasite load on Bavarian bats
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Bats serve as hosts for different ectoparasite families, but with the regression of the bats the existence of their parasites is endangered as well and some species are regarded as being threatened by extinction in Germany. To investigate the nearly unknown Bavarian bat ectoparasite fauna, 927 bats of 19 Bavarian bat species (*Barbastellus barbastellus*, *Eptesicus nilssonii*, *E. serotinus*, *Myotis bechsteinii*, *M. brandtii*, *M. daubentonii*, *M. emarginatus*, *M. myotis*, *M. mystacinus*, *M. nattereri*, *Nyctalus leisleri*, *N. noctula*, *Pipistrellus nathusii*, *P. pipistrellus*, *Plecotus auritus, P. austriacus*, *Rhinolophus ferrumequinum*, *R. hipposideros*, and *Vespertilio murinus*) were investigated with regard to their ectoparasite load. Collected parasites were determined in the lab by light microscopy respectively scanning electron microscopy. Altogether, nine flea species of the family Ischnopsyllidae, three bat-fly species (Nycteribiidae) and two bug species (Cimicidae) could be found. In the Acari four species of ticks (Ixodidae and Argasidae), seven species of the family Spinturnicidae, six of the Macronyssidae and *Nycteridocoptes poppei* (Sarcoptidae) as well as *Trombicula russica* (Trombiculidae) were found parasitizing Bavarian bats. For some species it is the first record in Bavaria and for the mite *Steatonyssus noctulus* also the first record in Central Europe.

A complex inter-species phylogeny reveals distinctive biogeographic patterns of diversification in triple nose-leaf bats (*Triaenops* spp.) in Madagascar

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The island of Madagascar has been isolated from other landmasses for the last 88 million years. This long period of isolation has resulted in a unique fauna, with high rates of endemicity among its native mammals, birds, fish, and reptiles. High levels of endemicity are found among Madagascar's bat fauna, as well, with 60% of native bat species being endemic, including one endemic family (Myzopodidae). We used mitochondrial DNA sequence data to examine phylogeographic structuring among species of the genus *Triaenops*. The species *T. furculus* and *T. rufus* are distributed sympatrically along the western coast of Madagascar, while *T. auritus* is known only from the type specimen collected from the extreme northern end of the island. A fourth species, *T. persicus*, is located in eastern Africa and Arabia. We found little differentiation among populations from throughout the range of *T. rufus*. Similarly, populations of *T. furculus* from west-central and southwestern Madagascar show little differentiation. However, populations from the northern portion of the range of *T. furculus* are significantly differentiated from other parts of the species (?) range, and morphological evidence indicates that these populations may instead belong to *T. auritus*. These data are consistent with two potential hypotheses as to the origin of the genus: 1) an African origin with multiple crossings of the Mozambique Channel separating Africa from Madagascar, or 2) a Malagasy origin with subsequent dispersal into Africa.

Distribution and status of Polish bats

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This review is based on all available published and unpublished information collected by the Authors till the year 2004. Elements of both south and north European bat fauna occur in Poland. Of 22 species recorded so far in the country, four groups may be distinguished in respect of their distributional characteristics. I. Species with no limit of distribution in Poland (15) including (a) these common and widespread (5): *Eptesicus serotinus*, *Nyctalus noctula*, *Plecotus auritus*, *Myotis nattereri*, *Myotis daubentonii* and (b) species reported from almost all parts of Poland but unevenly distributed; more abundant in some parts of the country while rare or vagrant in another (10): *Myotis mystacinus*, *M. brandtii*, *M. dasycneme*, *Vespertilio murinus*, *Eptesicus nilssonii*, *Pipistrellus pipistrellus*, *P. pygmaeus*, *P. nathusii*, *Nyctalus leisleri*, *Barbastella barbastellus.* II. Species reaching the north or north-eastern edge of their distribution range in the Polish lowlands (3): *Myotis myotis*, *M. bechsteinii*, *Plecotus* *austriacus*. III. Species confined to the Karpaty Mountains, Sudety Mountains and Kraków-Czêstochowa Upland (3): *Rhinolophus hipposideros, Myotis emarginatus* and *Rhinolophus ferrumequinum* (except for Sudety Mountains; only six records in Poland). IV. Species of unknown status (1): *Nyctalus lasiopterus* (recorded 1–2 times). A species richness gradient, with the number of species increasing from north to south, reflects climatic and topographic differences of Poland. The highest number of species (19–21) occurs in Kraków-Czêstochowa Upland, Karpaty and Sudety Mountains (south Poland), while the lowest (13–14) – in the north-eastern regions. *Rhinolophus hipposideros*, *M. emarginatus* and *M. dasycneme* classified as endangered and *M. bechsteinii* – as near threatened, are the rarest of Polish breeding species. In contrast to situation in Western Europe, *M. myotis* and *B. barbastellus* are relatively common and not regarded as threatened.

Bats of Albania: state and knowledge and recent records from one of the least studied European countries

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Bat fauna of Albania belongs to the least studied among European countries. The occurrence of 24 (21) bat species, of which ca. 50% known from only single localities, has been reported from the country till the year 1996. They are as follows: Rhinolophidae —*Rhinolophus blasii*, *R. euryale*, *R. ferrumequinum*, and *R. hipposideros*; Vespertilionidae — *Myotis myotis*, *M. blythii*, *M. bechsteinii*, *M. nattereri*, *M. emarginatus*, *M. mystacinus* sensu lato, *M. daubentonii*, *M. capaccinii*, *Vespertilio murinus*, *Eptesicus serotinus*, *Nyctalus leisleri*, *N. noctula*, *Pipistrellus kuhlii*, *P. nathusii*, *P. pipistrellus* sensu lato, *Hypsugo savii*, *Plecotus auritus*, *P. austriacus* sensu lato, and *Miniopterus schreibersii*; Molossidae — *Tadarida teniotis*. In the result of recent taxonomic revisions several new species appeared in European fauna. Since there are no specimens available for the investigation the status of *M. mystacinus* and *P. austriacus*, reported from Albania before the year 1996, remains unclear and needs confirmation. During the two field trips, organized by the authors in August 2003 and April 2004, 23 bat species were recorded at new localities in different parts of Albania, including the north of the country, from where no records existed previously. Among them are: *Myotis aurascens*, *Pipistrellus pygmaeus*, *P. pipistrellus* and *Plecotus macrobullaris* – reported for the first time. Moreover, we found several new localities of *N. leisleri*, *M. bechsteinii* and *P. auritus* previously known only from single specimens. *Hypsugo savii*, formerly regarded as rare in the country, appeared to be the commonest bat of the northern mountains. Nowadays, the bat fauna of Albania comprises 26 species but it seems to be still far of to be completed. Further studies in taxonomy and zoogeography are planned by the authors in the years 2005–2007.

Adaptation of brain regions to habitat complexity: a comparative analysis in bats (Chiroptera)

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Vertebrate brains are organised in modules, which process information from sensory inputs selectively and are therefore probably under different evolutionary pressures. We investigated the impact of environmental influences on brain structure in bats, using regions associated with hearing, olfaction and spatial memory. We compared wing area, as a correlate of habitat complexity with the size of these regions, while controlling for phylogeny and body mass. The inferior colliculi, the largest sub-cortical auditory centre, showed a strong positive correlation with wing area in echolocating bats. However, increasing adaptation to complex habitats in echolocating bats did not influence the auditory nuclei, a conglomerate of nuclei associated with hearing. The pteropodids, although not echolocating, showed improved hearing abilities along with increasing adaptation to dense habitats. The size of the main olfactory bulb did not increase with wing area suggesting that olfaction may not be used for the localisation of food and orientation. As expected, adaptation to structured habitat was linked to a larger hippocampus in all bats. Our results suggest that morphological adaptations related to flight and sizes of brain regions co-evolved under similar ecological pressures. Thus, we show that habitat complexity selectively influences and shapes sensory abilities.

Adaptive significance of male sociality in temperate bats

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Most temperate bat species show the classic three-phase annual social structure termed the temperate cycle. In two phases, during hibernation and mating, social structure in these species is characterised by mixed sex associations. During parturition, however, sexes segregate. Females mostly aggregate in maternity roosts forming groups of a few to thousands of individuals, whereas males of most species are solitary. However, a few species, for example *Vespertilio murinus* and *Nyctalus noctula*, form so-called bachelor groups consisting of dozens of males roosting together. Much effort has been allocated in investigating the adaptive value of sociality and the social organization in bats by studying female associations. In this talk we focus on potential factors leading to male sociality during parturition in those temperate bat species that display this unusual social system. We use data on wing-morphology and diet in a comparative analysis to correlate factors associated with foraging ecology and the occurrence of male sociality. Male sociality seems to be influenced by the foraging ecology in the species analysed. Open aerial insectivores and water-surface foragers show a higher tendency for male aggregations. The bias in scientific attention towards female sociality in bats is unfortunate, because more data on male sociality are needed to understand the evolution of sociality in bats in general.

Echolocation and morphological characteristics in two similar European rhinolophids

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Rhinolophus euryale and *R. mehelyi* are morphologically very similar species whose distribution range overlaps largely in the Mediterranean basin. The aim of this study was to compare the ecomorphology and echolocation of both species to get an insight in to the potential differences in their habitat use. The study was carried out in a mixed colony located in a dehesa-like landscape in the Sierra Norte Natural Park, Seville, southern Spain. Bats resting frequency was recorded using a time-expansion Petterson D-980 ultrasound detector and a DAT recorder and also body mass, forearm length, wing-length, wing-area, wing-load, aspect-ratio and Wing Shape Index were measured. *Rhinolophus mehelyi* showed a significantly higher resting frequency than *R. euryale* (*R. mehelyi* = 106.8 kHz; *R. euryale* = 104.4 kHz), although values overlap extensively. Body mass, forearm length, wing-length and wing-area were significantly larger in *R. mehelyi.* The higher values in aspect-ratio and wing-load and lower value in Wing Shape Index reduce maneuverability and agility in *R. melehyi*'s flight. Thus, the higher habitat complexity, the lower ability of *R. mehelyi* to manage in it. We would then expect a habitat separation of the two species along a clutterness gradient of the foraging areas.

Products of fermentation and other possible odor cues for bats

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Yeasts occur in all fleshy fruits and metabolize sugars to obtain energy. In this process, these yeasts produce alcohols and other chemicals, ethanol being the main by-product. It has been hypothesized that fruit-eating bats use the volatile products of fermentation as odor cues to find fruits and assess their palatability. We used the Egyptian fruit bat, *Rousettus aegyptiacus,* to test the prediction that concentrations of ethanol similar to those in ripe fruit attract the bats, whereas higher concentrations, as might be found in overripe fruit, are deterrent. The odor of aqueous ethanol solutions (0.001%, 0.01%. 0.1%, and 1%, v/v) was not attractive to the bats compared to plain fruit juice or water. Solutions of ethanol in mango juice with concentrations from 0% to less than 1% were equally preferred. By contrast, those above 1% were avoided. *R. aegyptiacus* is able to use ethanol vapor as a cue to choose food, avoiding ethanol concentrations higher than 1%. Since the percentage of ethanol in ripe wild fruits varies from ~0.01% to ~1%, these results suggest that the ethanol emitted from fruits may be used by *R. aegyptiacus* to recognize unpalatable fruit. We also analyzed volatile substances emitted from two species of fruit (in different stages of ripening) consumed by the *R. aegyptiacus* under aerobic and anaerobic conditions. Preliminary data suggest that products of fermentation different from ethanol, as well as other alcohols that are not products of fermentation, may serve as odor cues for fruit-eating bats.

Flyways of commuting vespertilionid bats at different background situations

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All bats use background structures for orientation and most of them follow stereotyped flight paths while commuting. Flight paths of individual bats are bundled to flyways and connect for example roosts with hunting areas. To study the dependence of flyways from background structures we recorded the flight and echolocation behaviour of 3 species of FM-bats (*Myotis daubentonii, Myotis brandtii* and *Pipistrellus pipistrellus*) with a 3D-video and a synchronized sound recording system. *Myotis daubentonii* was studied in three different situations: Flying along the edge of a forest (tree height 25 m), along the edge of a building (height 3 m), and along a road bordered on both sides with dense vegetation forming a vegetation tunnel of 6 m width and 11 m height. In edge situations the flyways were rather wide. Individual routes were found at 2–6 m horizontal distance to the edge and 2–5 m vertical distance to the ground. In the vegetation tunnel the flyway was more narrow and closer to one side as to the other. Most routes were found within 2–3 m horizontal distance to the closer edge of the 6 m wide tunnel and 2–3 m above ground. Within the vegetation tunnel the flyways of *M. brandtii* and *M. daubentonii* were rather similar. The flyway of *P. pipistrellus* was somewhat more extended in vertical direction with individual routes in 2–4 m above ground. In all situations the echolocation behaviour is described by pulse interval, pulse duration and bandwidth.

Effects of emotion on bat communication calls

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Acoustic communication plays a prominent role in the social behaviour of bats. Consequently, rich social call repertoires have been found, typically consisting of sequences of short syllables specifically combined in different social contexts. While call parameters mediating group-, gender- and individual-specific signatures have been described, the question of how bats transmit emotional states acoustically has not been addressed, so far. As a first functional hypothesis, I postulated that the parameters irrelevant for identification may inform conspecifics about the affective state of the caller. A review of bat communication literature revealed that emotions may be preferably coded in sequence parameters, e.g. the number of syllables, total call duration, and the overall frequency contour of a call. This hypothesis was tested by examining the structure of landing strophes of the Indian False Vampire, *Megaderma lyra*, emitted by identified individuals in two situations representing different arousal states: when the bat landed without physical contact to others, or during landings resulting in direct body contact. Parameters tested were the number of syllables in a strophe, the median intersyllable intervals and the median peak frequency of the strophe. The number of syllables was increased and the median intersyllable intervals tended to decrease in situations with body contact. This provides is a first experimental evidence for an effect of the emotional state of the caller on sequence parameters, thus confirming our hypothesis. In contrast, the median peak frequency did not differ significantly in the two situations, and may convey individual- rather than emotion-specific information.

Multimodal foraging behaviour in *Megaderma lyra*: strategies, environmental constraints and psychoacoustics

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Foraging of mobile prey comprises its initial detection and localization, its identification and discrimination, and finally its successful tracking and capture. The present paper focuses on the question of how passive listening and echolocation interact during the different stages of foraging in the Indian False Vampire, *Megaderma lyra*. This bat is carnivorous and feeds both on airborne insects, and on vertebrates and insects gleaned from substrates. First we present experimental evidence for foraging by means of echolocation and passive listening, respectively. We show that either strategy is sufficient for successful foraging in this species, given the animals are confronted with appropriate experimental designs. Then we discuss two major constraints on echolocation and passive listening promoting multimodality in the natural environment, i.e. echo clutter and noise background. Finally, we consider the psychoacoustic constants characterizing hearing sensitivity, masking, time perception and sound lateralization in *M. lyra* that pose constraints on echo and prey sound perception as well as on sonar call design in this species.

Categorization of vegetation in Natterer's bat, *Myotis nattereri*

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Natterer's bats are specialized to forage close to vegetation. Classification of vegetation would give the bats the advantage to recognise profitable foraging areas. Most vegetation is characterized by many reflecting facets (leaves, needles, twigs) that generate echo trains each different from the next. Theoretically, the random process parameters of such trains can be used to categorize plants. We wanted to know whether bats use this information to recognize plants while foraging. We trained 4 individuals of *Myotis nattereri* in a flight room to catch tethered mealworms positioned close to an artificial leaf tree. At the same time we also presented an artificial needle tree without prey. The positions of the trees were randomly varied. To measure the attractiveness of the two tree types we introduced trials without prey and measured how often the bats circled around the trees and made capture attempts. The bats clearly preferred the leave tree even when we varied between 4 different types of leaf and needle trees. When changing the reward from the leave to the needle tree the bats preferred the needle tree after a few rewarded trials. This indicates that bats categorize vegetation by echolocation and use this information as indicator for profitable foraging areas.

The influence of prey defense, competition and environmental factors on the structure of insectivorous bat ensembles in South Africa

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We tested the influence of biotic (moth defences and competition) and abiotic factors (environmental factors) on the structure of seven insectivorous bat ensembles representing different geographic regions in South Africa. In all ensembles peak echolocation frequency was significantly correlated with the incidence of moths in the diets of the bats. This suggests that prey defence is an important factor in structuring these ensembles. We used wing and echolocation parameters to calculate the distance in morphospace between the species of ensembles, and between species in functional groups (clutter/edge and clutter foraging species) within each ensemble. If competition has influenced the structure of these ensembles, the species comprising them should be more regularly spaced and the distance between them should be larger than that in ensembles randomly drawn from regional species pools representing different biogeographic scenarios. Univariate null model analyses revealed that species were regularly spaced in 50% of ensembles and minimum distances between species were significantly larger in 20% of ensembles. In contrast, these distances were significantly less than expected in 70% of ensembles. Multivariate null model analyses, using minimum spanning trees determined by the first two principle components of wing and echolocation parameters, found species nearer than expected from each other in morphological space, but nevertheless evenly spaced. We therefore conclude that prey defence and environmental constraints on wing and echolocation parameters are the main factors structuring these ensembles and that competition played a minor role, if any.

Habitat selection and home ranges of four sympatric species of European horseshoe bats
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We studied four species of horseshoe bats in Northern Bulgaria by telemetry in the years 2001–2003. *Rhinolophus euryale*, *R. ferrumequinum* and *R. mehelyi* were tracked from one colony site in the lower Osam valley, *R. hipposideros* from several nearby roosts. From a total of 39 successfully tracked individuals, 3392 bearings of foraging individuals in their hunting grounds were obtained. Home range (MCP), core foraging area (50% Kernel) and range span were used to characterise and compare the foraging areas. *Rhinolophus hipposideros* had the smallest home ranges with range spans lower than 5 km, followed by *R. ferrumequinum* and *R. mehelyi*. *Rhinolophus euryale* had the biggest home ranges with range spans of more than 20 km. We mapped the whole range of all tracked bats, using 17 different habitat classes, as a basis for determination of habitat preferences. While habitat types of all species showed a big overlap, we could find some species-specific preferences. *Rhinolophus hipposideros* was the only species foraging in rural areas of the habitat type village. *Rhinolophus euryale* foraged most of the time in dense vegetation (scrub, forest) while *R. mehelyi* preferred open habitats (meadows, agricultural fields). The preliminary analysis of the data supports a possible habitat partitioning between those two species.

Conserving New Zealand long-tailed bats: a local initiative
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The endemic New Zealand long-tailed bat, *Chalinolobus tuberculatus*, is an endangered species. Decreases in distribution are mainly attributed to forest clearance and the failure of bats to survive in open country and urban areas. This study focuses on one of the few bat populations surviving in an agricultural area. Fewer than 200 long-tailed bats live in South Canterbury in the South Island, and their numbers are declining. Productivity and survival in this population is significantly lower than bats inhabiting unmodified indigenous forest. Research identifies one of the main factors contributing towards this decline is loss of high-quality roost sites. In the absence of indigenous trees, most bats roost in introduced willows. These trees do not provide optimum conditions for rearing young, and allow easy access for introduced predators. In 2003, a conservation management programme aimed at restoring roosting and foraging areas, and controlling predators was initiated. It involves local farmers, non-government conservation organisations, the New Zealand Department of Conservation, and local government. For example, the Royal Forest and Bird Protection Society developed a sponsored artificial-roost box scheme. In conjunction with many local people and researchers from the Department of Conservation, 100 Schwegler roost boxes of 4 designs are currently being trialled. This poster shows a copy of an information panel sited in the centre of highest bat activity and the site of the artificial-roost box trial. The aim of the panel is to increase awareness of the plight of local bats.

Sexual segregation and mating strategies in *Myotis daubentonii*

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We investigated sexual segregation in Daubenton's bat and its consequences for mating strategy and male mating success. In an upland valley the majority of the males roosted at higher elevations, separately from the females and the minority of the males, who roost and forage together. Ringing showed that these summer populations did not mix over several years of study. 'Upstream' males foraged for longer, traveled further when foraging and were significantly lighter than downstream males of similar skeletal size. Upstream males could be excluded from the better quality downstream habitat, or their lower wing loading could be a consequence of mass regulation to reduce flight costs, compensating for their longer foraging times. We hypothesised that if upstream males were competitively excluded this would imply reduced fitness and lower mating success. We tested this hypothesis using microsatellite-based paternity analysis. Paternity was highly skewed towards downstream males, with only a few offspring fathered by upstream males and those visiting swarming sites in the autumn. The results imply that two mating strategies may be operating, one at summer sites and a second, later in the season at swarming sites.

Bat associations in a group of non-breeding Mehely's horseshoe bat, *Rhinolophus mehelyi,* kept in a flight cage

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A group of thirteen (8 females and 5 males) Mehely's horseshoe bats, *Rhinolophus mehelyi,* kept in a flight cage during autumn and winter were subjected to random availability of roosts of different size. On the basis of weekly photographs taken from different groups of bats occupying various roosts average distances between individuals were calculated in order to identify consistency of bat associations formed in the flight cage. The average centrality (mean distance between any individual with all other individuals) was used to identify relationships between body mass and sex of individuals and their position in the groups. It was discovered that in large roosts (18 cm in diameter) random changes in the number of roosts (1–6) did not affect the grouping of bats. In small roosts (14 cm in diameter) random changes (1–6) caused splitting of single associations into either two or three ones. Results obtained in this experiment suggest that, regardless of the size of groups, females with higher body mass tend to have lower social distance ($r^2 = 0.77$) indicating that larger individuals tend to locate at the centre of groups. In males, no significant correlation ($r^2 = 0.02$) between body mass and social distance was detected.

On occurrence of *Myotis capaccinii* (Bonaparte) in western Iran

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Myotis capaccinii has only been reported from southern Iran in five localities close to each other within a radius of approximately 100 km. Our research provided opportunity to report on external and cranial characteristics for four *M. capaccinii* in two new localities in western Iran not previously known as a habitat for this species. Average external and cranial characteristics for the four specimens ranges well within the published values for *M. capaccinii* indicating that the individuals occurring in western Iran belong to *M. capaccinii bureschi*.

Postnatal growth in four infant Kuhl' bats, *Pipistrellus kuhlii,* reared in a flight cage

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This study documents the postnatal growth of body mass, forearm and the epiphyseal phalangeal gap in four Kuhl's bats, *Pipistrellus kuhlii*, that were born and reared in a flight cage. The pups at birth had a mean (± SE) body mass of 0.75 ± 0.03 g and forearm length of 8.55 ± 0.11 mm. At 60 days, mean body mass was 90.6% of adult mass (4.35 ± 0.03 g) and mean forearm length was 89.4% of adult length (30.4 ± 0.04 mm). The length of forearm and body mass increased linearly during first 3 weeks, and thereafter rached an apparent stability. The epiphyseal gap of the fourth metacarpal phalangeal joint increased until 12 days, then decreased linearly until 50 days and thereafter fused. The rate of body mass gain and forearm growth during the first 24 days were 0.14 g/day and 0.85 mm/day, respectively.

Diversity pattern in the diet of Mehely's horseshoe bat *Rhinolophus mehelyi* in three contrasting environments in western Iran

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The diet of *Rhinolophus mehelyi* was investigated through analysis of droppings collected from three maternity roosts in northern Zagros, mid-Zagros and northern Mesopotamian plain in western Iran. Lepidoptera dominated in all regions (34.9–69.5% diet volume). Coleoptera (12.6–28.2% volume) were the 2nd most important food item in the northern Mesopotamian plain and mid-Zagros, whereas Homoptera (16.0% volume) were the 2nd in order in northern Zagros. Feeding habits of *R. mehelyi* in northern Zagros are characterized by low occurrence of Coleoptera (10%) and presence of more diverse prey species (12 categories). In northern Mesopotamian plain and mid-Zagros the food items consist mainly of lepidopteran/coleopteran taxa with less complementary prey species. Animal groups restricted to the food of *R. mehelyi* in northern Zagros are Odonata, Trichoptera, Dictyoptera and Acarina.

The amplitudes of arthropod rustling sounds can explain the apparent prey selectivity in the ground-gleaning bat *Myotis myotis*

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When studying prey selection in bats, we generally compare prey availability in their respective habitats with prey actually found in the bats' diets. However, this approach does not allow distinguishing between active prey selection (where the bat makes a foraging decision to capture or to reject a certain prey) and passive prey selection (where the bats' sensory access to prey limits the prey spectrum). The greater mouse-eared bat, *Myotis myotis,* is known to forage nearly exclusively on epigaeic arthropods and to find them using the rustling sounds they produce. We determined the acoustic conspicuousness of different taxa and size classes of ground arthropods by measuring several amplitude parameters of their locomotion sounds. Within taxa, we found a clear positive correlation between size and amplitude. Within a given size class, carabid beetles were louder than lithobiids and much louder than iulids. We quantified prey selectivity of *M. myotis* in Switzerland. Medium sized and large carabids, large lithobiids and cursorial spiders were strongly overrepresented in the diet as compared to their abundance. Small carabids and lithobiids were strongly underrepresented and several taxa did not occur in the diet at all (Isopoda, Iulidae, Glomeridae, Geophilidae), irrespective of their size. When matching the diet analysis with the rustling sound measurements, it was obvious that the overrepresented prey types were consistently louder than the underrepresented types. Thus, we can most parsimoniously explain the apparent prey selectivity in *M. myotis* by the acoustic conspicuousness of potential prey and by the species' specific sensory ecology.

Size discrimination of hollow hemispheres by echolocation in the nectar feeding bat *Glossophaga soricina*

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In contrast to the ability of insectivorous bats to detect flying prey against an open sky, echoacoustic detection and identification of motionless objects in highly cluttered surroundings seem to be a difficult task. Nectar-feeding bats exploit flowers in dense tropical vegetation using acoustic features of the flowers for detection. They are able to perform up to several thousand decisions per night. Thus, they are well suited to test object discrimination based on echolocation in training experiments. We asked which echoacoustic information the bats use to discriminate between objects of the same shape but of different size. As objects we chose hollow hemispheres. Individuals of the nectarivorous bat *Glossophaga soricina* were simultaneously confronted with a set of seven differently sized hollow hemispheres. Only one size was rewarded with a small amount of sugar water. The distribution of visits at the seven hemispheres was measured. In a test situation the set was presented without reward. Only visits obtained during test situations were used as data. We also measured the echoes of the hemispheres, as well their strength and their spectral features. The echoes were constant over a wide angle of sound incidence and each size had its own characteristic spectral pattern. Our results suggest that echoacoustic size discrimination follows the Weber-Fechner-rule: The minimum size difference between simultaneously presented hollow hemispheres, which the bats were able to discriminate, was a constant percentage of the absolute hemisphere's size. Three echoacoustic features may be evaluated by the bats: the overall echo level, the spectral pattern and the temporal structure of the echo. Considering our echoacoustic measurements, we suggest that the most important cue used by the bats is the spectral pattern, something like the "colour" of the echo.

Nectar feeding behaviour of pteropodid bats on *Ceiba pentandra*

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The Indian flying fox, *Pteropus giganteus* (body mass ca. 1000 g) and the short-nosed fruit bat, *Cynopterus sphinx* (ca. 50 g) regularly visited the inflorescences of kapok trees, *Ceiba pentandra,* to feed on nectar through out nights. The fulvous fruit bat, *Rousettus leschenaulti,* (ca. 100 g) also visited the flowers, but its visits were restricted to the early parts of nights. Peak visits of bats occurred during pre-midnight hours, coinciding with maximum nectar production and sugar concentration of floral resources. *C. sphinx* foraged at 6–10 m, *R. leschenaulti* at 10–18 m, and *P. giganteus* at 15–20 m heights. Chemiluminescent tagged *C. sphinx* foraged on nectar in single trees until midnight and moved over to two to four nearby trees during later hours. Among the mist-netted bats 26 *C. sphinx* and four *R. leschenaulti* had pollen coats at ventral abdomen, wing membranes and heads. Pollen loads at abdomen were significantly more in males than female *C. sphinx*. Even though we have mist-netted *P. giganteus*, our visual observations showed adherence of pollen grains on their face, throat and chest. Presence of pollen grains on the bodies of *C. sphinx* and *P. giganteus* and their foraging heights suggest that these bats pollinate the flowers in the lower and upper parts of *C. pentandra* trees, respectively. *R. leschenaulti* may play a minor role in pollination.

Mycotic infection of the skin of *Phyllonycteris poeyi* associated with necrotizing dermatitis and non-suppurative arthritis

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Seven adult *Phyllonycteris poeyi* (3 males, 4 females) were sent to the Institute for Zoo and Wildlife Research, Berlin, Germany, for diagnostic investigations. Grossly all bats had marked unilateral or

bilateral symmetrical swelling of their carpal joints. Most individuals had lost the claw of the diseased thumb. Microscopically there was extensive necrotizing dermatitis covered by crusts of cellular debris with orthokeratotic hyperkeratosis of the adjacent epidermis. Multiple septated fungal hyphae were located within the epidermis or within the cartilage of the first phalangeal joint. The underlying dermis was markedly distended by clefted connective tissue sparsely infiltrated by lymphocytes, plasmacells, macrophages and some neutrophilic granulocytes. Multifocally sheaths of tendons close to the dermal changes comprised intense inflammation with infiltration of mononuclear cells. Microbiological investigation of phalanx 1 and pollux revealed the presence of gram-positive (*Staphylococcus intermedius, Enterococci,* aerobic sporeforming rods) and gram-negative (*Enterobacter cloacae*) bacteria and different fungi (*Trichoderma* spp., *Chaetomium globosum, Penicillium* spp., *Mucor racemosus*). All isolated fungi have been described to occur on skin and hair as well as in feces of bats. Little is known about the pathogenicity of these micro-organisms in bats. Their possible role in the disease process is discussed.

Echolocation behavior of two gleaning phyllostomid bats catching katydids in the air

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Insectivorous leaf-nosed bats (Phyllostomidae) are mainly known as gleaning bats that take stationary food from surfaces. However, flight cage experiments on foraging behavior and detection mode of two phyllostomid gleaners, *Tonatia saurophila* and *Micronycteris hirsuta* revealed that both species pursue and catch insects also in the air. To date, the ability to switch between gleaning and aerial hawking has only been shown for non-phyllostomid species. Characteristically, bats that track moving prey in the air emit feeding buzzes shortly before capture to gather more information about its position. In contrast, bats that glean prey from surfaces generally lack a terminal phase since they use prey-generated cues for localization. In our behavioral experiment we tethered katydids, still enabling them to fly, and compared approach sequences of both species. We simultaneously recorded echolocation calls and 3D videos of foraging bats to assign changes in call characteristics to changes in foraging behavior. Calls of both species were steep frequency-modulated, multiharmonic and short. *Tonatia saurophila* emitted approach calls nearly twice as long as calls of *M. hirsuta*. Both species reduced call duration with decreasing distance to the katydid and increased repetition rate by decreasing pulse interval. However, no bat performed feeding buzzes when catching flying katydids. Signals produced at the end of the final approach overlapped with returning echoes from prey. We conclude that even though the bats track moving prey, both species do not depend entirely on information from echolocation but use flight noise as passive-acoustic cue to track and locate their prey.

Pollination of *Cleome spinosa*: sphingids moths and glossophagine bats

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Cleome spinosa (Capparidaceae) is an herb that occurs along riverbanks in the semiarid northern Neotropics. Flowers are white, delicate and suggest sphingophily. However, nectar is presented in large droplets and is easily accessible. Following initial observations of bat visitation, we studied pollination biology of this plant in Colima, Western Mexico. The flowers opened in late afternoon and nectar production started around sunset. Average nectar production was 204.7 ± 34.8 µl per flower per night, sugar concentration during peak production was around 13%. On each inflorescence, an average of 4 flowers opened per night. Among these, 22% were hermaphrodites, 75% males with reduced stigma and 3% females with reduced stamen. Flowers occurred in densities of up to 60.3 open flowers per m^2, which resulted in local nectar densities of 12.3 ml per m^2 per night. This quantity represents almost the daily nectar requirement of a small glossophagine bat. Flowers were observed from February to April and from August to October, indicating a very long flowering period. We videotaped bats and sphingid moths visiting the flowers in the rainy season, however, we did not see sphingid moths in the dry season. Mistnetting near flowers revealed *Leptonycteris curasoae* and *Glossophaga soricina* as bat visitors. Additionally, we found pollen of *C. spinosa* on the pelage of two more species, *Anoura geoffroyi* and the rare, highly specialized nectar bat *Musonycteris harrisoni.* The pollination syndrome of *C. spinosa* encloses characteristics that regularly attract both bats and moths. Future studies should incorporate an evaluation of the pollination efficiency of the bats and sphingids.

Coexistence in *Myotis nattereri* and *M. bechsteinii*: do differences in sensory ecology contribute to resource partitioning?

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Nursery colonies of Natterer's, *Myotis nattereri*, and the long-eared Bechstein's bats, *M. bechsteinii*, roost in bat boxes in the same orchard in southern Germany, and both forage in forests and orchards nearby. Observations and behavioural experiments with freshly captured *M. bechsteinii* showed that individuals were able to hunt using prey-generated sound alone. In contrast, *M. nattereri* has previously been shown not, or hardly ever, to use prey-generated sounds. Instead, it uses echolocation to detect prey, such as spiders on threads, very close to but not in contact with, vegetation. It also scoops arthropods from plant surfaces using its tail membrane, presumably in random attacks at prey-rich sites that it recognises using echolocation. We hypothesised that these differences in the sensory ecology of two syntopic, congeneric species would contribute to resource partitioning, since *M. bechsteinii* would hunt more noisy arthropods while *M. nattereri* would have access to non-moving prey. Analysis of faecal samples collected, on the same nights, from bat boxes occupied by each species revealed that the most important prey categories for *M. bechsteinii* in the study area were indeed moths, earwigs and ground beetles, all of which are noisy and likely to have been gleaned among vegetation. *Myotis nattereri* fed mainly on silent prey that could have been caught in the air close to vegetation or gleaned from plant surfaces. Its most important prey groups were cyclorrhaphan flies, spiders and crane flies. As predicted, the diets of the two potentially competing species differed significantly, reflecting their different prey perception techniques.

A complete interfamilial molecular phylogeny illuminates Chiropteran biogeographical history

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Bitter scientific debates in mammalian evolutionary history have stemmed from the interpretation of alternative phylogenies acquired with different data types and reconstruction methods. This has been most apparent within the Order Chiroptera. To date, there are approximately 1,110 extant bat species, globally distributed, and second only to rodents in terms of species numbers and ecological diversity. Despite their numbers, the biogeography and evolutionary history of bats are both controversial and poorly understood. This has been attributed to an impoverished fossil record, controversial phylogenetic hypotheses and constraints on morphological evolution imposed by flight. To address these questions and discriminate between the competing phylogenic hypotheses we sequenced 13.7kb of nuclear sequence data from portions of 17 nuclear genes for representatives of all bat families and four laurasiatherian outgroups (30 bats, 4 outgroups). This is largest molecular data set both in terms of taxonomic diversity (first time a representative of each bat family is included in a molecular phylogenetic analysis) and number of base pairs. The basal divergence dates, of all major clades, were estimated using Bayesian analyses and constraints from the fossil record. The new timescale, coupled with the complete phylogeny illuminates and differentiates between competing bio-geographic hypotheses. Funded in part by DHHS NO1-CO-12400.

Bat Research in the Department of Zoology, Yangon University, Myanmar

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Currently 94 species of bat have been recorded from Myanmar, with a further six new country records awaiting publication. This rich diversity is partly a consequence of the zoogeographical position of Myanmar. The bat fauna has affinities to the Indian Subcontinent, Southeast Asia, Central Asia and the western Palaearctic. It is also a result of the wide range of habitat types available within the country, ranging from lowland tropical forests to high glaciated mountains in Kachin State. In 1999, a programme of bat studies was initiated by the Zoology Department of Yangon University in association with the Harrison Institute. This enabled the Department to meet its dual obligations of promoting biodiversity conservation in Myanmar and meeting the challenges of the 'knowledge age' by promoting education through collaboration with international NGOs. In June 2000, a MoU was signed between Yangon University and the Harrison Institute and following support by the 100% Fund of Fauna and Flora International the programme of bat studies was awarded a Darwin Initiative grant in April 2002. Study topics include aspects of biodiversity techniques, systematics, echolocation, ecological studies, behavioural studies, environmental education and conservation biology. To date, ten field surveys have been conducted throughout the country by the bat group that comprises nine student/staff members of the University supported by staff of the Harrison Institute. An international workshop was hosted by Yangon University in October, 2002, and subsequently the bat group had the opportunity of working with scientists from Australia, India, Malaysia, Portugal and the United Kingdom. Notable achievements include the identification of 8 cave sites, which are roosts for the globally endangered bumble-bee bat, *Craseonycteris thonglongyai*.

Polyunsaturated fatty acids and hibernation in bats: problems extrapolating from diet analysis to the true composition of depot fats

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Most heterothermic mammals increase the proportion of polyunsaturated fatty acids (PUFA) in their body fats prior to entering torpor. Because PUFA have low melting points, it is thought that they play an important role in maintaining the fluidity of depot fats and membrane phospholipids. Indeed, it has been suggested that PUFA is essential for hibernation. In a recent review of the role of PUFA in the expression of torpor (Munro and Thomas, 2004), we pointed out that vespertilionid bats and echidnas had exceptionally low dietary PUFA content compared with hibernating rodents (bats: 15%; rodents: 44%). Dietary PUFA intake for bats was estimated from fecal analyses made in summer and the PUFA content of various insect taxa. Because bats hibernate as deeply as rodents (body temperature <5°C), we argued that PUFA may not be as essential to the expression of deep torpor as was previously thought. However, recent analyses of the depot fats of hibernating *Myotis lucifugus* and *M. septentrionalis* show that they have PUFA contents roughly equivalent to those of hibernating rodents. We suggest that either bats shift their diets in late summer to include PUFA-rich taxo during the fattening period or that they are able to preferentially retain PUFA over monounsaturated and saturated fatty acids. We caution that behavioural analyses may not always allow us to predict physiological responses.

Installation of a network on the Mammals in an institution of forestmanagement: the Office National des Forêts (France)

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In the face of the erosion of the biodiversity in forests, particularly in the Tropics, the concern of the scientists relates to the capacity of the forest world to integrate this component in the production targets of wood. In France, the Office National des Forêts manages 8% of the territory, corresponding to 4,525,000 ha (national forests). Becoming aware of the importance to the patrimonial character of the grounds that it managed, this structure set up many biological reserves, whose objective is conservatory management. But the stake of conservation is such, that ONF set up a network mammals at the beginning of year 2004, in the objective to integrate these animals in the management of the French forests. This network must meet several aims, of which: 1) to ensure the scientific watch on the subject of mammals and forest. This shutter of its activity will make it possible to follow in detail the evolution of knowledge, and to hold informed the forest manager on the evolution of the practices applicable to the management of the forests in France for the conservation of these animals; 2) to translate and disseminate scientific and naturalist information near the people who manage the forests; 3) to take part in knowledge, by setting up follow-ups; 4) to train the field staff for the best taken into account of the mammals in the management of the forests. The network is also the occasion to support studies aiming at refining knowledge of the ecology of the species, and their relationships to the forest ecosystem. It supports for example a study on the impact of French forest management on bats, in their part of tree-life. The installation of a naturalist network in a structure of management of the forests appears to be a solution to manage the forests effectively in a conservatory way for the Mammals. It is also the best means of making adhere all the forest personnel of the institution, and of ensuring a bond uninterrupted with the scientific world.

Methodology for the study of bat roosting in temperate forests: preliminary test in the National Forest of Rambouillet (France)

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Bats are an important component of the biodiversity in temperate forests. In France, forests play today a major role in the conservation of bat species, as they are usually less degraded than other ecosystems. They are used as foraging areas and also, for several species, as roosting places. The objective of this study was to provide forest managers with tools for the conservation of bat roosts. Six stations were described in 2003 in the National Forest of Rambouillet (France). A large set of variables was recorded in each station at different scales: environmental variables at the scale of planting (density of trees, average height of trees, presence of water,…), variables related to the individual trees (species, height, diameter, foliage,…), variables taken from the cavity (height of the entrance, exposure, depth,…). Data were mainly analyzed with logistic regressions. Thanks to the significant number of described trees (4000) and cavities (565), we are able to identify the internal and standard height cavity, height and depth of its entry, the position of the roost in the tree, the forms tree (branches spread out with large low branches and a sparse foliage, large trunk, and dominant class), and the density of cavities and the number of decaying trees 30m around the roost-tree as the most important variables for bat roosting in the Rambouillet's forest. Then we suggest a methodology, taking into account only the most relevant variables at different scales, that could benefit both the conservation of bat roosts and the exploitation of the forest. However these results are still too restricted to provide guidelines for the management of every European temperate forests. So, this methodology is being tested right now on other forests, and for other forestry management.

Establishing a Western Indian Ocean regional group for the IUCN/SSC Chiroptera Specialists Group

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The IUCN / SSC Chiroptera Specialist Group (CSG) encourages the establishment of regional groups to co-ordinate bat conservation needs and activities within a region, and provide a source of relevant information. A regional group is being established for the Western Indian Ocean (http://horus.cs.nott.ac.uk/WIO/) to cover: Madagascar; Mauritius and Rodrigues; Seychelles and Aldabra; the Union of the Comoros; the French departments / territories of Mayotte and Réunion; the Tanzanian islands of Mafia, Pemba and Zanzibar; and the Socotra Archipelago (Yemen). Madagascar and the West Indian Ocean (WIO) Islands have a high level of biodiversity and endemism. Around 64 species of bats (15 Megachiroptera and 49 Microchiroptera) are found in the Western Indian Ocean region; five of these are currently listed as Critically Endangered (3 Megachiroptera and 2 Microchiroptera) and one Megachiroptera species went extinct in 19th Century.

Education, education, education! Lessons from conservation initiatives for the Critically Endangered fruit bats *Pteropus livingstonii*, *P. rodricensis* and *P. voeltzkowi* in the Western Indian Ocean, concerning locally-based bat population monitoring programmes

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Pteropus livingstonii, P. voeltzkowi, and *P. rodricensis* are three Critically Endangered fruit bats found on Western Indian Ocean islands that are threatened by habitat loss and persecution. Surveys in the 1980s and 90s indicated populations of less than 200 bats for all three species. As a result, multi-disciplinary conservation initiatives that included environmental education programmes were established for these bats. These environmental education programmes were important in increasing local awareness about the bats and their conservation, establishing community-based environmental NGOs, and supporting bat population monitoring programmes. In all three cases, the monitoring programmes with their considerable local involvement have revealed bat populations that were larger than originally thought. Current estimates are ~1,200 for *P. livingstonii*, ~5,100 for *P. rodricensis*, and ~6,900 for *P. voeltzkowi*. The education programmes have also had direct conservation outcomes and impacts for these bats. Important lesson for conservation can be learnt by comparing the successes and failures of existing programmes, by regularly evaluating programmes, and by recognising the need for multidisciplinary approaches and effective partnerships between local and international organisations.

Hovering thieves and perching pollinators: bat pollination of *Calyptrogyne ghiesbreghtiana*

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The inflorescences of the Central American understory palm *Calyptrogyne ghiesbreghtiana* offer bats fruit-like flower tissue as reward for visitation. Bats visited the inflorescences in two different modes: frugivores (Phyllostomidae: Stenodermatinae, Carolliinae) perched on the inflorescence for foraging, whereas primarily nectarivorous bats (Phyllostomidae: Glossophaginae) hovered briefly in front of the inflorescences to consume flower tissue. Using infrared video I observed 23 female inflorescences in order to relate visitor behavior to subsequent fruit set on the respective inflorescence. Although most of all observed visits (n = 2916) to *C. ghiesbreghtiana* inflorescences were performed by hovering

Glossophagines (94%; mainly *Glossophaga commissarisi*), total time spent in contact with the inflorescence was higher in perching Stenodermatines (82.2% from a total contact time of 4 h 16 min 15 s; small *Artibeus* spp.). While Glossophagines always removed only a single flower per visit, perching Stenodermatines consumed between 1 and 147 flowers per visit. Fruit set was significantly lower in inflorescences that had received only hovering visits, indicating that perching behavior offered better possibilities for pollen transfer. While the pollination system of *C. ghiesbreghtiana* is probably adapted to perching, predominantly frugivore bat visitors, hovering Glossophagines also exploit the inflorescences, yet they are less efficient pollinators. From the plant's view the nectar-specialist Glossophagines are non-optimal participants that profit from an otherwise evolved pollination system. Seen in an evolutionary perspective the *Calyptrogyne ghiesbreghtiana* – glossophagine bat interactions may demonstrate recruitment of new pollinators from non-destructive visitors to flowers.

Hitchhikers on bats: flower mites travel on bats between inflorescences of *Calyptrogyne ghiesbreghtiana* (Arecaceae)

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We present the association between a new species of flower mite (tribe Melicharini) and neotropical flower-visiting bats. Analogous to the well-known hummingbird – mite interactions these mites use bat visitors to inflorescences of the lowland tropical palm *Calyptrogyne ghiesbreghtiana* as a means to travel to new inflorescences. Flower mites were found to occupy 76% of all active inflorescences surveyed. However, newly opened inflorescences were mite-free. In spite of a Tanglefoot® barrier on the peduncle that prevented colonization by walking animals, numerous mites appeared on these "crawling-exclusion" inflorescences within a few days, indicating they had arrived by air. Visitors to the *Calyptrogyne* inflorescences were caught with mistnets near the plants. While *Calyptrogyne* received visits from both hovering Glossophagines (*Glossophaga commissarisi*, *Hylonycteris underwoodi*) and perching Stenodermatines (*Artibeus watsoni / phaeotis*) as well as Carolliines (*Carollia brevicauda*), only the latter were found to carry mites, indicating that the fast visits of hovering glossophagine bats (> 1 s) might not allow mites to mount the bats. In contrast, *Artibeus* spp. that occasionally perched for several minutes carried up to 19 mites per individual, mainly on the wings. Phenology data show a tight coupling between the occurrence of mites on bats and flowering phenology of *C. ghiesbreghtiana*, suggesting that the palm is the most important host for the mites.

Ecology of the specialized nectar-feeding bat *Musonycteris harrisoni*

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We studied the natural history and diet of the trumpet-nosed bat, *Musonycteris harrisoni*, a extremely rare nectar-feeding bat endemic to Western Mexico and explored potential reasons for the morphological cranial specialization of this extraordinarily long-snouted bat. We worked in Colima, mainly in small banana plantations adjacent to natural "selva baja" vegetation. Among hundreds of other nectarivorous bats (*Glossophaga soricina*, *Anoura geoffroyi*, *Leptonycteris curasoae*) we captured 28 *M. harrisoni* in the wet and 30 in the dry season. This represents the largest data set in existence for this species. We took morphological measurements of each bat and collected pollen from its pelage and faecal samples. Preliminary dietary analysis revealed various species of cacti, and the genera *Ipomoea*, *Ceiba*, *Cleome*, *Pachira* (*Pseudobombax*), *Crataeva*, *Agave* and *Helicteres* as components of the diet. Capture rates for *M. harrisoni* were lowest during the main flowering time of columnar cacti, indicating that the banana plantations support the population mainly during times of low nectar availability of native plants. So far, we found no indication for a tight relationship between *M. harrisoni* and particularly long-tubed

flowers that would obligatory require a long rostrum for exploitation. However, we found a significant sexual dimorphism in rostrum length. Males had significantly longer snouts (ca. 9 %) than females, suggesting that the enormously long snout is not necessarily shaped by direct foraging requirements alone, but perhaps also influenced by – so far unknown – intraspecific interactions.

Evaluating the performance of Climatic Envelope Models (CEMs) in predicting regional patterns of bat distribution

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Maps of species distribution are vital tools in conservation planning. Yet, the gathering of detailed data on species distribution is time and money consuming. Ecological niche modeling may serve as an alternative way of generating satisfactory maps of species distribution. Climatic Envelope Models (CEMs) define the potential geographic range of a species by the totality of sites with environmental conditions similar to those prevailing at the sites for which records of that species are available. Even though such models are widely used in the literature, only few studies have been designed to systematically evaluate the performance of alternative models using independent data. The present study compares the performance of three different CEMs (BIOCLIM, Habitat and Mahalanobis) using data on 13 bat species in Israel. The models were calibrated using data compiled from several different sources including field observations and museum specimens. Model predictions were tested against independent data obtained from an extensive field sampling project that was planned with the aid of a GIS. There was no significant difference between the models in their ability to predict species distribution. Overall prediction accuracy was found to be relatively high. We conclude that CEMs can be used as an effective tool for predicting regional patterns of bat species distribution.

The rate of brain cell's generation in the adult microbats

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In all investigated mammalian species, except of the adult *Sorex* shrews, throughout life new neurons are generated in the subventricular zone (SVZ) of lateral ventricles and migrate to the olfactory bulbs (OB). The second place of generation is the dentate gyrus (DG) of hippocampus. It is postulated that new neurons in the DG play an important role in reworking of the spatial or emotional memory and in the OB they participate in refining discrimination of new odors. Therefore, the rate of generation of new cells in both structures is very important for the physiology and behavior of bats. We investigated the presence and rate of generation of newly generated cells in the brains of four species of microbats (*Rhinolophus hipposideros*, *R. euryale*, *Miniopterus schreibersii*, *Barbastella leucomelas*) captured in Armenia. The animals were sexually mature adults. Bromodeoxyuridine (BrdU) was injected as a marker of nuclei of the newly generated cells. Animals survived 24 h after injections. BrdU was later detected immunohistologically in sections of their brains. We found that in all investigated bat species new cells were generated in both SVZ and DG. The rate of generation to OB was always much higher. Species differences will be discussed.

Seasonal foraging movements of the Mediterranean horseshoe bat, *Rhinolophus euryale* Blasius, 1853 (Rhinolophidae), revealed by radio-tracking

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Seasonal foraging behaviour regarding spatial use of a colony of *Rhinolophus euryale* (Rhinolophidae) was investigated in an Atlantic landscape of the Basque Country (Southwestern Europe).

Bats were fitted with radio-transmitters and tracked in pre- (n = 13), during (n = 15), and post-breeding (including nine young and five adults). We hypothesized that foraging flight distances would be shorter and feeding sites smaller in lactating females and the young, due to energy requirements and novelty in flying and orienting, respectively. Flown distances and size of foraging areas were measured analyzing data with a GIS. Flown distances to foraging areas were significantly shorter in pre-breeding season and for the young. Interestingly, lactating females did not show neither shorter traveling distances nor smaller foraging areas. Indeed, size of foraging areas showed greater variability within than between seasons. We consider that the causes of these results would be related with an interaction between the distribution of prey, which might be irregular, and the size of the colony and hence bat density at feeding sites.

Phylogenetic relationships among recent chiropteran families and the importance of choosing appropriate outgroup taxa

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Results of recent molecular studies cast doubt on the validity of the superorder Archonta, suborders Mega- and Microchiroptera, and infraorder Yinochiroptera and has even led some to consider novel alternatives for the evolution of flight and echolocation in mammals. At present, higher-level relationships within Chiroptera still are without consensus and much of this controversy is related to howbats are related to other mammals and also to relationships among family-level lineages within Chiroptera. Although this controversy superficially manifests as differences in the relative merits of morphologic versus molecular data, both classes of data are themselves conflicting. We contend that much of the discrepancy among these studies is due to improper choice of outgroup, limited taxonomic sampling, or both. We examined approximately 3 kb of mitochondrial DNA from 104 bats representing the taxonomic, geographic, and morphologic diversity within all families (except the monotypic Craseonycteridae) and 58 additional taxa representing 12 other orders of mammals. Results of our analyses strongly support other recent work indicating that Archonta is not a natural assemblage and that the sister taxon to Chiroptera may include Cetartiodacptyla, Perissodactyla, Carnivora, and possibly Pholidota. Using representatives of these taxa as outgroups to evaluate interfamilial relationships within Chiroptera we detected strong support for recognition of the suborders Yinpterochiroptera and Yangochiroptera. Within Yangochiroptera, our analyses strongly support expansion of the superfamily Noctilionoidea to include the New World Thyropteridae and Furipteridae.

Implications of wing morphology and flight performance in the dietary selection and feeding habits of Salim Ali's Fruit Bat, *Latidens salimalii*

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Morphology of an animal reflects its ecology. Flight has enabled bats to exploit a variety of foraging niches inaccessible to other mammals. Observations on wing morphology and flight performance were made on the Salim Ali's fruit bat, *Latidens salimalii.* According to IUCN Red List Criteria Version 3.1 the only Megachiropteran bat species endemic to south India and endangered is *L. salimalii*. The study was made on the recently discovered three populations of this species in the Agesthiyar hill range of Tirunelveli India. Agesthiyar hill range is internationally recognized for its natural richness and for high levels of floral and faunal endemism. The morphological parameters of *L. salimalii* were measured by following the methods described by Norberg and Rayner (1987). The flight performance calculations were calculated from regression equations in Rayner (1988) and Norberg (1990). The present studies on the foraging behaviour of this bat species revealed that they forage for fruits in relatively tall trees in evergreen forests of this hill range, at an altitude of above 1,100 m. The present analysis shows that the wing morphology of this bat has great influence on its flight performance, which is correlated with its foraging behaviour and diet. The fresh remnance of these fruit bats collected at their night roosts suggests that these bats play a major role in the seed dispersal of some of the fruit trees, which are endemic to southern Western Ghats of India. In this way they replenish the forest ecosystem at an altitude above 1,200 m height.

Ecology of a maternity colony of *Myotis emarginatus* (Chiroptera: Vespertilionidae) in an artificial cave in the region Veneto (N.E. Italy)

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The only known maternity colony of Geoffroy's bat, *Myotis emarginatus*, in the region Veneto (N.E. Italy) occupies an artificial cave, placed in an historic romantic park in the municipality of Mirano (Venezia). This colony, regularly monitored starting from 2001, has provided some new information on the dynamics of bat nursery of this species in Italy. The colony (with about 40 individuals – mothers and young – at the end of the reproductive cycle) is present in the roost for only 8–9 weeks per year, from the end of May, to the end of July. In this brief period females give birth and wean their young. Bats present high mobility within the cave, utilizing several different sites. While emerging from the roost at dusk, *M. emerginatus* individuals show a clear preference for the darkest places, whereas the illuminated areas are occupied by Kuhl's pipistrelle, *Pipistrellus kuhlii*, catching over the cave hill and the castle. The analysis of faecal pellets, demonstrates a diet specialized on spiders (Aranea) and Diptera (especially Calliphoridae) during May–July, with other minor groups also represented (Lepidoptera, Coleoptera, Hymenoptera, Hemiptera, Neuroptera, Opiliones). A long series of restoration works, in the castle and in the caves, have provided great disturbance to the colony, also during the reproductive period; but, unexpectedly, these bats, apparently sensible to human disturbance, remain in the cavity showing a limited damage. On the opposite, a little colony of *Rhinolophus ferrumequinum*, ecologically associated with the reproductive females of Geoffroy's bat, present a dramatic decline up to extinction in 2004.

Are harems harems?

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Polygyny is the most common mating system not only within the class of Mammalia but also within the order Chiroptera. Our current knowledge of polygynous mating systems has greatly advanced during the past decade owing to new molecular techniques. In this presentation I will review and summarize recent studies of the harem-polygynous mating system of *Saccopteryx bilineata* (Emballonuridae) and compare it to other bat mating systems. Early field studies in the seventies described the basic social units in colonies of *S. bilineata* as harems, implying that harem defenders monopolize the reproduction within their territory. Recent paternity studies revealed that harem defenders sire, on average, only 30% of the offspring within their harem. Female *S. bilineata* are superior to males during agonistic encounters, probably because of their large size. Thus, females can choose freely among males of a colony. Several male traits are probably under sexual selection, such as male songs and male body scents. Males have specialized wing sacs in which they store scent from their gular and genital glands. Hovering males display their perfume in front of females. Recently, we demonstrated that small or symmetric males sire more offspring than large or asymmetric males. Small size and symmetry could be beneficial for aerial manoeuvers, such as hovering flights. Summarizing, I argue that the so-called harem social structure in daytime roosts of *S. bilineata* has more similarity to a lek system from a functional perspective than a harem system in the traditional sense. But, in contrast to the textbook definition of a lek, male *S. bilineata* defend resources and females remain in the male territory during the entire year.

Nitrogen and stable carbon isotopes in the study of bat ecophysiology

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During the past decades an increasing number of stable isotope studies has been published on bats. In most of these investigations nitrogen isotopes are used to assess the trophic position of bats and the origin of dietary nitrogen, whereas stable carbon isotopes are used to study trophic interactions, food chains and migratory patterns. Despite the fact that stable isotopes have become an important tool in the study of bat ecophysiology, some underlying assumptions have not been tested adequately. In this presentation, we review our current knowledge about the use of stable isotopes in bats and point out some obvious and hidden methodological caveats. In addition, we present a study in which we have used stable carbon isotopes to unravel the host preference of parasitic *Desmodus rotundus* and superparasitic batflies living on vampire bats. In the same study, nitrogen isotopes were used to evaluate the trophic position of vampire bats within the host-parasite-superparasite food chain.

Chiropteran phylogeny – the karyological view

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Traditionally, the order Chiroptera is divided into two suborders, Megachiroptera and Microchiroptera. In the recent years, several molecular genetic studies revealed a closer relationship of Megachiroptera (flying foxes) and Rhinolophoidea, questioning Microchiropteran monophyly. Using conventional techniques, karyotype comparison of different bat families seemed impossible due to extensive chromosomal evolution. With the development of fluorescence-in-situ-hybridization techniques, however, detection of homologous chromosomal segments became possible. We used human whole chromosome painting probes to study the karyotype composition of six bat families. These experiments showed three clearly separated lineages: First, the Yangochiropteran families Vespertilionidae, Molossidae and Phyllostomidae are closely related. Second, the rhinolophoid families studied, Rhinolophidae and Hipposideridae share three synapomorphic features. The third lineage is made up by *Eonycteris spelaea*, the only megachiropteran species studied, showing several plesiomorphic characters. Due to the fact that Rhinolophoidea share features with Yangochiroptera as well as with Megachiroptera, the relationships between this three lineages must be left in an unsolved trichotomy at the moment. We hope that further studies, for example comparison with related mammalian orders, e.g., Insectivora, could help to elucidate chiropteran phylogeny.

Lubee Bat Conservancy: research projects and worldwide conservation programs for fruit and nectar bats

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Lubee Bat Conservancy is an international non-profit organization working with others to save fruit and nectar bats and their habitats through conservation, research and education. Healthy ecosystems depend on fruit and nectar bats that pollinate flowers and disperse seeds. These bats are among the least studied and most threatened animals in the world. Lubee is working to promote understanding and responsible management of the vital relationship between bats, plants and people, leading to a sustainable future for all. Lubee works with a world-wide team of conservation scientists, educators and zoological institutions to link field studies with research at our premier center for bat research, and to support conservation programs that build capacity of communities to conserve fruit and nectar bats and their essential ecosystem services through education and outreach. We present an overview of the current diverse research and conservation programs being supported by Lubee worldwide. These include projects examining the aeromechanics of highly maneuverable bats, physiology and behavior in the social Malayan flying fox and solitary golden-mantled flying fox, development of an enzyme linked immunosorbent assay for detecting antibody responses in the Island flying fox, community led population monitoring of the Madagascar flying fox, population monitoring of Malayan flying foxes in the Philippines, the relationship between seeds, pollen and forest regeneration by the Malagasy straw-colored fruit bat, and the Island Bats Conservation Initiative.

Study of diseases and causes of death in native bat species in Germany

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In Germany 25 different species of Microchiroptera have been detected; 20 of these are known to breed in maternity roosts. Despite numerous studies about the behaviour and environment of the different bat species little information is available regarding their diseases and causes of death. The knowledge of infectious agents in bats as well as possible diseases is rather limited and reports from Europe and particular Germany are sparse. So far, being a potential zoonosis, most interest was placed in rabies research. Multiple studies concerning the existence of different strains of rabies virus in bats have already been performed (Dr. T. Müller) and are still subject of research. Other pathogenic agents like bacteria, fungi, viruses and parasites have only been examined with minor attention. Therefore we are planning investigations regarding infectious agents, diseases and causes of death of native bat species by histopathology, microbiology and electron microscopy to gain deeper inside into their relevance for bat populations and individuals. As only very fresh carcasses, which have to be deep frozen as quickly as possible, can be examined the number of samples will be limited to moribund individuals resp. animals killed in an accident. Therefore we would like to introduce our project to conference participants for discussion and raise the awareness of this study to people working with bats.

Flower visiting bats (*Glossophaga soricina*) feed nectar to offspring

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Raising offspring is a highly energy consuming task, which is taken over by the mother in all bats mainly by breastfeeding. Only a few bat species are known that do not exclusively feed their young with milk: e.g., in *Desmodus rotundus* mouth-to-mouth feeding of blood has been described. We found that the flower visiting bat *Glossophaga soricina* feeds young with nectar. This behavior starts in the late lactation period before the young is able to visit flowers independently. We tried to quantify the volume of nectar transferred by the mouth-feeding. We used pollen as a marker: The captive bats were fed on a solution of honey, water and pollen for a short time (2–3h). The feeder as well as the roosting site were monitored by an infrared video camera. Afterwards we collected feces of mother and young and counted the pollen grains. With help of the defined concentration of pollen in the honey solution and the analysis of the videomaterial we were able to calculate that the young received a volume of 0.1–3.4 ml of nectar by mouth-to-mouth-feeding per night. This is equivalent to a volume of up to 25% of the nectar requirement. A female feeds its young during one night about 80 times, on average every 10 minutes. We suppose that mouth-feeding with nectar beside its energetic value helps to adapt the digestive system to the change of food, and allows the young to learn smell and taste of specific flowers.

Heavy metals assessment in the fur of *Myotis myotis* from Poland

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Samples of fur of *Myotis myotis* were collected in the late summer (2000 and 2001) from eight maternity colonies in Southern Poland. The samples were rinsed to avoid external contamination and then analysed by means of atomic absorption spectrometry for six elements: Zn, Cu, Pb, Cd, Hg, and As. The concentration of these elements differed between two studied areas and between the single colonies. There was also a considerable difference between the years; however, the concentration of elements in the fur of adult females and young individuals was similar. The results indicate that hair samples from bats may yield important information on the contaminants in their habitat.

The influence of anthropogenic factor on the dynamics and biology of bats in karst caves of Armenia and the Republic of Nagorno-Karabakh

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There are 27 species of Chiroptera in Armenia and all of them were investigated by the authors. Largest populations of bats are found in the karst regions where there are many of caves, sometimes forming labyrinths. The best known are caves of Magil, Arjer and Mozrov in Armenia and caves of Azokh and Shushi in Artsakh. The anhropogenic factors exerted appreciable consequences on some regions of both Armenia and Nagorno Karabakh. These consequences are often negative, generally affecting the ecology in general as well as some species of animals (Insectivora, Chiroptera, Rodentia, Carnivora) in particular. However, this influence may sometimes have positive effects, providing source of food and shelter for certain species. As a part of these investigations, karyology of seven species (*Rhinolophus ferrumequinum*, *R. euryale, Myotis blythii, Miniopterus schreibersii, Barbastella leucomelas, Pipistrellus kuhlii,* and *P. pipistrellus*) from two families (Rhinolophidae, Vespertilionidae) has been researched. Comparative analysis of the karyotypes showed high homology of all investigated species.

Foraging activity of Central European *Myotis myotis* in a landscape dominated by spruce monocultures

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In Bavarian forests dominated by spruce monocultures, 10 *Myotis myotis* (9 females, 1 male) radiotracked in summer 2002 near Augsburg (Swabia) did not actively select stands of deciduous forests but used them according to their availability. The bats preferred tall single strata forests with little undergrowth. The 26% of the foraging time was spent outside forests in meadows and fields. An explanation for the existing relationship in Bavaria between population density of the ground gleaning *M. myotis* and the extent of deciduous forests appears to be the higher percentage of open floor suitable for foraging in old beech forests and beech-mixed forests compared to old stands of spruce. A major recommendation from our study is that in order to preserve the high density of *M. myotis* in Bavaria, the use of beech in forestry and reintroduction of cattle grazing in forests should be increased to compensate for a decreasing foraging area of *M. myotis* in spruce dominated forests.

Inferring population history from genealogies: preliminary data on European long-eared bats, *Plecotus* (Chiroptera)

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The history of populations that postglacially re-expanded into Central Europe may largely depend on their ecological adaptation. Species adapted to the cold are more likely to have survived Pleistocene glaciations in multiple northern refugia, whereas species adapted to a warmer climate may have re-immigrated from southern refugia. To test this hypothesis of contrasting expansion patterns we compare the genetic population structure for differentially adapted species: the brown long-eared bat *Plecotus auritus* that is adapted to mountainous areas up to 1200 m a.s.l. and the grey long-eared bat *Plecotus austriacus*, which is regarded a typical lowland form. Here we present preliminary results of partial sequences of the mitochondrial control region (D-loop) for more than 400 individuals of both species form over 50 sites, most of them from Central Europe. Both phylogeographic patterns are still in line with our expectation of multiple versus single sources of Central European populations.

Research and conservation of bats in China

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One hundred ten to one hundred twenty species of bats have been recorded in China until now. However, few studies have been carried out on these flying mammals in this large country. In this presentation, we will give a report on the current status of bat research and conservation, the relationship among bats, human being and local economy. At the same time, we will also present the results of our research work on different aspects of different bat species: 1) The diet of *Myotis ricketti* was analyzed by examining its feces, and by directly observing in the field. It was found that the diet included evidences of feeding on three kinds of little fish and at least five orders of aerial insects. This study alleged the previous suspicion that *M. ricketti* is a fishing bat; 2) Echolocation calls of 7 species of rhinolophids and 4 species of hipposiderids were recorded in China. No significant correlation between body mass and call frequency was found in the 7 species of rhinolophid bats. However, an intimate negative relationship was found within Rhinolophidae between call frequency and ear length. The ear length was proved to be a more important morphological parameter to influence the call frequency in rhinolophids but not in hipposiderids; 3) Phylogenetic relations among five species of Hipposideridae and seven species of Rhinolophidae including one endemic species (*Rhinolophus rex*) were examined by partially sequencing of the mitochondrial cytochrome b gene (528 bp). Analyses of the cytochrome b sequences of Hipposideridae and Rhinolophidae suggest that each formed a monophyletic group. All phylogenetic analyses indicate that *Aselliscus* should remain as a genus within Hipposideridae, with the mean percentage sequence differences (16.43%) and transition:transversion ratios (2.032) between *Aselliscus* and *Hipposideros*.

Peculiarities of the prenatal development of digestive system of bats

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The canalization of processes of the laying, development and functioning of digestive system in onto- and phylogenesis is universal for all mammals. A significant difference in duration of the embryogenesis and amount of the embryos at investigated mammals of the comparable sizes (Chiroptera: *Rhinolophus ferrumequinum*, *Myotis blythii*, *Nyctalus noctula*; Rodentia: *Mus musculus*) is reflected in different intensity of growth of embryos as a whole and organs of digestive system, but not on a degree of their differentiation. The comparative analysis of the embryos of the investigated Chiroptera and Rodentia species at late stages of development (21–23 stages) has shown, that in this period the formation both differentiation of tissues and organs of digestive system is finished and is shown species specificity (in the form and topography of a stomach, pancreas and liver, different length of the departments of intestine, formation and orientation of intestine loops etc.). One of the peculiarities of development of digestive system in the bats is the slow growth of the hindgut, which keeps the primary location, and also it is possible to qualify presence of structures and functions identical by those small intestine (villi, Paneth cells, activity of the digestive enzymes), that as recapitulation, which is in the postnatal period promotes increase of efficiency of digestion of food. Heterochrony, which are shown in one longer prenatal development of bats (hence, and the greater duration of separate stages of development) in comparison with others mammals of the similar size, obviously, are connected first of all with key in evolution Chiroptera morphogenesis of the locomotion organs of a qualitatively new type. The mechanism of prolongation of the prenatal development of bats, probably, consists in their ability to decrease in body temperature and metabolic rate and, in this connection, delay all physiological and morphogenetic processes.

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 at 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

Bats of the Rocky Mountain West: natural history, ecology, and conservation.
Adams, Rick A. 2003. University Press of Colorado, Boulder, CO. 289 pp. ISBN 0-87081-736-1.

This book is concerned with bats of the U.S. Rocky Mountain states: Idaho, Montana, Wyoming, Utah, Colorado, Arizona and New Mexico. It is partly a field guide and partly a primer for those interested in bats, and it is intended for both specialists and laypeople.

The first part of the book covers the biology, ecology, evolution, and conservation of bats in the Rocky Mountain states. It includes: (1) a general introduction to the Chiroptera, including their structure, diversity, echolocation, and importance; (2) the region's geography and life zones, and how they relate to the distribution of bats; (3) what is known about the evolution of bats and how they have adapted to temperate environments; (4) how the regional bat assemblage is structured, in terms of ecomorphology, foraging strategies, and patterns of habitat use; and (5) regional conservation issues and conservation efforts. This introductory part of the book highlights many unique and fascinating aspects of bat biology and would be an interesting read for those new to bats. However, I found the writing style somewhat dramatic, and while it may convey a sense of wonder, I was expecting a more scientific style. Many concepts are well-illustrated by photographs, drawings, and figures. Nevertheless, several figures could have been improved by the addition of explanatory legends and by more careful proof-reading. For example, figure 1.12 shows overlapping echolocation calls, and the captions for figures 1.11 and 3.4 refer to the wrong colors. Figure 5.8 features abbreviations that are not explained, and figure 2.14 (a confusing depiction of the Chihuahuan faunal element) is not explained at all.

The second part of the book consists of accounts for the 31 bat species found in the area. A dichotomous key precedes the accounts, but its usefulness is limited by multiple errors in numbering that make it impossible to key out molossids correctly. Each account includes region-specific data on ecology, behavior, reproduction, and development, as well as the species' conservation status according to the Western Bat Working Group. A color photo, a regional distribution map, morphological measurements, and a description of the bat's echolocation behavior are given as aids to identification. For many species, a spectrograph of an example call sequence recorded with Anabat is included, although the author rightly cautions that a reference call library should be used for accurate identification. Characteristic call shapes and frequencies (but unfortunately not duration) are given, though the source of this information is unclear.

In general, the biological information in this book is easy to understand, but at times accessibility comes at the expense of scientific rigor. Some concepts are simplified to the point of being misleading or wrong. For example, the description of bat-moth interactions is not entirely correct, and explanations of the foraging behavior of *Myotis evotis* and *M. auriculus* imply obligate gleaning, when in fact these species forage by aerial-hawking as well. Several factual errors also decrease the book's usefulness as a scientific reference. For example, the insect order Trichoptera (caddisflies) is confused with Neuroptera (lacewings) throughout; *Lasionycteris noctivagans* is identified as a foliage-rooster in Table 4.1, and the use of echolocation and passive audition by *M. evotis* is inaccurately described in two places. As is usual with this sort of book, only select references are cited, making it difficult to follow up on some of the statements made. A lot of the data appear to be based on relatively old sources, particularly Mammalian Species Accounts.

This book's greatest strength may be as a source of region-specific data. The two appendices could be especially useful. A summary of conservation programs is a good starting point for people interested in bat conservation. As well, a bibliography of government publications about bats, organized by state, contains references that may otherwise be hard to find. In general, I found the book to be an interesting read, but I was disappointed at the number of errors. For this reason (and those given above), the book will probably appeal more to a layperson than a specialist.

Joanna M. Wilson, 343 Biological Sciences, University of Calgary, Calgary, AB T2N 1N4
jowilsonca@yahoo.ca

FUTURE MEETINGS and EVENTS

February 2005
Annual meetings for the Colloquium on the Conservation of Mammals in the Southeastern United States and the Southeastern Bat Diversity Network (SBDN) will be held in February 2005 at Paris Landing State Park in Tennessee (**http://www.state.tn.us/environment/parks/parks/ParisLanding**/). More information will be available on the SBDN website (**http://www.sebdn.org**)

July 31- August 5, 2005
The 9th International Mammalogical Congress will be held in Sapporo, Japan, and will include a symposium on "Ecology and Conservation of Bats in the Pacific Rim." For information about presenting at the bat symposium, please contact: **funakoshi@int.iuk.ac.jp** Additional information about the symposium and Congress is available at: **http://www.imc9,jp**

August 2005
The next European Bat Research Symposium will be held in Ireland in August 2005. More details will appear here as they become available.

October 19 - 22, 2005
The 35th Annual North American Symposium on Bat Research, will convene in Sacramento, CA, October 19-22, 2005. Winston Lancaster will host the Symposium. For additional information see our web-site at: **http://www.nasbr.org/** or contact Margaret Griffiths: **mgriff@illinoisalumni.org**

October 18-21, 2006
The 36th Annual North American Symposium on Bat Research, will convene in Wrightsville Beach, NC, October 18-21, 2006. Mary Kay Clark will host the Symposium. For additional information see our web-site at: **http://www.nasbr.org/** or contact Margaret Griffiths: **mgriff@illinoisalumni.org**

ANNOUNCEMENTS

Second Ouachita Mountain Bat Blitz
July 31st - August 4th, 2005

The Ouachita National Forest, in partnership with the Arkansas Game and Fish Commission and Southeastern Bat Diversity Network, is very excited to host the *Second* Ouachita Mountain Bat Blitz!

The Study Area
The Blitz will focus on the Poteau, Cold Springs, and Fourche Ranger Districts located in the northwest Arkansas portion of the Ouachita National Forest bordering the Arkansas River Valley. Net sites will be located on Federal, state, and private property in Scott, Logan, and Yell counties. More information about the Ouachita National Forest can be found at the following web site:
http://www.southernregion.fs.fed.us/ouachita

Blitz Headquarters
Base of operations will be Rogers Scout Reservation (RSR) in Ione, Arkansas, just off AR State Highway 23 in Logan County. RSR is located 12 miles southwest of Booneville, 18 miles northeast of Waldron, and approximately 45 miles from the Fort Smith metropolitan area.

Totaling over 2,800 acres, RSR facilities include a 250 person dining hall (open air) with full kitchen, an air-conditioned health lodge, an air-conditioned 2-story training lodge, three 8-person cabins with ceiling fans, hot showers, and ample sites for tent camping. On-site recreation opportunities include an archery range and 22-rifle range in addition to swimming, fishing, and canoeing on 115-acre Lake Keenan.

Air-conditioned sleeping quarters are limited at RSR. The second story of the air-conditioned Training Lodge is the single largest air-conditioned sleeping space and is an open-room (barracks) that can accommodate approximately 20 individuals. Lodging and meals will be provided at RSR, only.

Contact Information
To receive Blitz updates and registration information, contact Frances Rothwein at 479.675.3233 or by e-mail: **frothwein@fs.fed.us**

Field Assistant Positions
January 2005 - September 2006

'Interactions of life history & stress physiology in tropical Chiroptera (bats)'

Fields of study:	Life history, endocrinology, immunology, metabolism
Methods:	Capture, marking and sampling of free-living bats/flying foxes
Positions available:	Two
Time frame:	Jan 2005 – Sept 2006
Locations:	(1) Barro Colorado Island, Panama (**http://www.stri.org**), Smithsonian Tropical Res. Institute (Jan-Feb, May-June 05 & July-Sept 2006) (2) Australian East Coast, Australia (**http://www.zen.uq.edu.au**) University of Queensland (Sept 2005 – Apr 2006) There will also be lab assistances at Ulm, Germany, in end 2006.
Duration:	6-12 weeks
Costs:	Own transport to study site, living expenses. There may be, however, some support available. We will provide help in finding stipends.
Own projects:	Possible

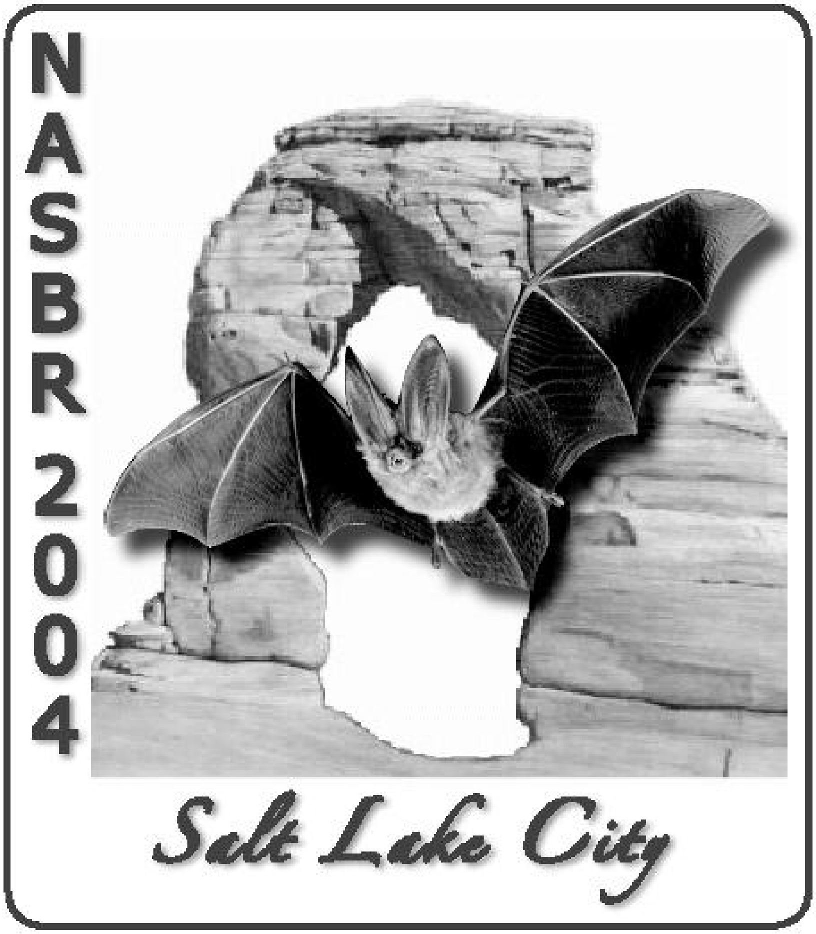
Previous field experience is desired, but not necessary. Applicants should feel comfortable working hard at night and in a tropical climate during the rainy season, plus be in good physical condition.

Expressions of interest are invited anytime
Contact Stefan Klose (**stefan.klose@biologie.uni-ulm.de**) before submitting an application including usual documents and two letters of reference.

University of Ulm, Department of Experimental Ecology (Bio3), Ecological Endocrinology Lab, Albert Einstein Allee 11, 89069 Ulm, Germany; Fon +40 731 5022668, Fax +49 731 5022683.

This project is supported by the Australian Government through the Endeavour Programme and by Boehringer Ingelheim Fonds (BIF).

BAT RESEARCH NEWS



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Front Cover

The cover logo was created for the 34th Annual North American Symposium on Bat Research, held in Salt Lake City, Utah, October 2004. The conference logo was designed by John Taylor and Michael Herder, and includes a photograph of *Corynorhinus townsendii* (Scott Altenbach, used with permission), and an original line drawing of Utah's Delicate Arch (Gary Christensen, used with permission).

From the Editor

Dear Subscribers to *Bat Research News*:

This is the fourth (and last) issue of *Bat Research News* for the 45-2004 volume-year, which means it is time to renew subscriptions to the journal. You will receive (or have already received) your renewal invoice either by e-mail or by post very soon. I hope you will consider renewing your subscription for another year or more.

Many of you have asked about paying for subscriptions by credit card, and I am pleased to announce that *Bat Research News* is now able to accept payment by Visa or MasterCard. To renew your subscription for the 46-2005 volume-year using a credit card, please go to the *Bat Research News* web site at **http://www.batresearchnews.org/** and click on the "Subscription Information" link. Subscription information and rates are available on the web site, as well as on the inside front cover of this issue. Alternatively, you may send me a check or money order payable to "***Bat Research News***" for the appropriate amount in U.S. dollars.

Also please note that Roy Horst has a new e-mail address (rhorst@twcny.rr.com). However, ever since his new e-mail was established, Roy has had problems with it, particularly problems with incoming messages. Therefore, in order to help him resolve these problems and to help test his new e-mail system, please send Roy a brief e-mail message when you have a few moments (once a month, once a week, or whenever you can) until these problems are resolved.

We would appreciate receiving news items about you, your bat-related work, fellow bat biologists, or bats, so please send these news items to us for inclusion in upcoming issues. Thank you for your continued subscribership.

Have a safe and productive year,

Margaret

Variation in Echolocation: Notes from a Workshop

S. C. Burnett[1], M. B. Fenton[2], K. A. Kazial[3], M. W. Masters[4], and G. F. McCracken[5]

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[5]*Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN 37996*

The Workshop

This report summarizes discussions that took place during a workshop at the Borror Laboratory of Bioacoustics, Ohio State University, Columbus, Ohio, on 12–13 April 2003. The goal of the workshop was to consider variation in echolocation calls of microchiropteran bats and its implications for bat behavior, species identification, and quantification of bat activity. We also discussed the need for standardized collections of calls. Participants (Appendix 1) represented a range of research interests and situations involving captive and wild bats and had experience with a variety of equipment and software. The authors of this report served as reporters, who compiled the following information and circulated it to other participants for comment. We hope that other biologists studying vocalizations of bats will find this information useful and thought provoking.

Variation in Echolocation Calls

Researchers working with echolocation calls as characteristics for identifying bats have experienced a paradigm shift. Models previously guiding research presumed that bat calls were stereotypic enough that call-based identifications ultimately would be routine in most cases, but now there is wider appreciation of intraspecific variation in echolocation calls. This, in turn, generates questions of how to incorporate such variation into models designed to identify calls, as well as questions concerning the causes and implications of such variation. We discussed seven elements contributing to the observed variability of echolocation calls: type of detector used, approaches to describing calls, type of statistical analysis, openness of the flight environment, age of the bat, geography, function of a call, and presence of other bats.

Differences in performance of different bat detectors

The array of commercially available bat detectors (and software) allows researchers to match equipment to the questions they address. The quality of a recording is largely dependent on the microphone of the detector. A microphone often is characterized by its sensitivity, which is the minimum strength of a signal that is detected, often expressed as decibels sound pressure level (dB SPL). Although the sensitivity of some microphones is flat across a range of frequencies, others are more sensitive to particular frequencies.

Inexpensive sources of ultrasound, such as electronic tape measures or dog whistles, can be used to standardize the sensitivity of several detectors at the particular frequencies emitted by the source, but this approach does not allow calibration over the range of frequencies commonly encountered in calls made by bats. Without calibration data, it is difficult to correct for differences among microphones or assess relative performance of detectors of the same or different model. Calibration curves that document the sensitivity of the detector across a range of frequencies would aid researchers in correcting for detector effects when several detectors are used. If curves were provided by manufacturers, this could reduce labor, ensure accuracy, and be less expensive than if each researcher acquired the measuring microphones and amplifiers needed for calibration. Bat-detector specifications that include frequency responses would allow researchers to select specific detectors appropriate for their particular project. Someone working on calls of *Tadarida brasiliensis*, for example, might select a microphone quite different from someone studying hipposiderids, due to differences in the frequencies used by these species (Jones et al., 1993).

We need to be able to correct our data for the variability introduced by our detectors, whether the goal is describing echolocation calls or monitoring activity. If detectors are calibrated by an individual investigator, resulting reports should provide enough details about the calibration to allow replication of the procedures. Although calibration can be important, if a study is designed simply to compare levels of bat activity by monitoring echolocation calls, randomized placement of detectors each night can help control for differences in microphone sensitivities without having to measure each microphone individually.

Researchers' approaches to describing echolocation calls

In studies of echolocating bats, one easily can collect large numbers of recordings, which presents problems in analysis of calls and ultimately of what to do with the data. Analysis of calls results in variables describing time, amplitude, and frequency. Although different researchers often attempt to describe the same features of echolocation calls, there is little standardization in the way that features are named, measured, or reported. For instance, most researchers provide some measure of call length over time. Generally this variable is called "duration," although other names are used, such as "call duration" or "pulse duration" (Table 1). In addition to different nomenclature, there are multiple methods for measuring duration (Table 1), so there is potential for confusion. Confusion also can occur because similar variables are given different names, such as terminal frequency, lowest frequency, minimum frequency, and ending frequency (Table 1). Although these variables are clearly related (most referring to the fundamental frequency at the end of the sweep of a call), it may not be clear how each was measured or how to convert between one measurement and another.

In the future, researchers should minimize the variance generated by lack of standardization of measurements and nomenclature. Standard features of calls should be measured in the simplest and most objective way to make the process repeatable and to minimize differences when more than one person (or system) is performing the analysis. Repeatability can be achieved through use of programs that automatically measure the parameters involved. This is possible only if researchers sufficiently detail their methods to allow replication of their analytical approaches. At the least, clear descriptions of the measurements used may allow other researchers to convert between the different measurements, making it possible to compare the results obtained.

Statistical analyses of call data

Automated systems for analysis of echolocation calls (e.g., Analook or suitable programs in Matlab) can generate large data sets describing echolocation calls. These data are readily used in statistical analyses assessing variation and using call variation in quantitative methods for classifying calls by species. Multiple analysis of variance (MANOVA) can be used to assess the incidence of significant interspecific variation that, when present, justifies use of either discriminant function analysis (DFA) or multiple logistic regression (MLR) to classify bats by their calls.

Users should be aware of the limits of DFA and MLR for assessing variation in calls (Burnett et al., 2001; Kazial et al., 2001). For example, when attempting to identify species, these techniques require that the researcher first designate the species that emitted a set of calls, potentially introducing human error in identification. In addition, no way exists to identify species not designated in the original set, again introducing the possibility of error. Some methods allow researchers to determine which variables are most suitable for describing variation present in a set of calls without using subjective criteria (e.g., principal component analysis or independent component analysis). Neural networks (NN) can classify individual bats (or species) by their calls but with some limitations (S. Burnett, unpublished data; Parsons, 2001; Parsons and Jones, 2000). The output of some NN programs may not show the features that allowed the placement of calls into groups, making it difficult for the researcher to know which features are relevant. One type of NN, called a self-organizing map, may be of particular interest because it does not require a priori classification of groups by the investigator (S. Burnett, unpublished data).

When classifying calls, multiple echolocation calls produced by the same individual cannot always be treated as independent data (Hurlbert, 1984; Surlykke and Moss, 2000). Calls of individuals are independent representations of the range of calls from that individual and could be used in individual classification, through such techniques as DFA. Consecutive calls of an individual, however, are likely more similar to each other than calls that are more widely spaced in time, so ideally, calls of an individual should be sampled at broad intervals if the goal is maximum statistical independence.

In contrast, multiple calls produced by the same individual cannot be treated as independent data when describing variation between groups (e.g., species or sex). For example, multiple calls from an individual female bat are not independent representations of the calls of all females. Treating multiple calls from one individual as independent and combining them with calls from other individuals, without using appropriate statistical methodology, would be pseudoreplication. One way to deal with this is to average parameters from given individuals and use the individual averages as independent representations of female calls (Burnett et al., 2001; Kazial et al., 2001).

Although calls from one individual are not independent, large intraspecific variation can occur within a single sequence (Murray et al. 2001; Obrist 1995). Researchers examining variation in echolocation calls must include calls from individuals in their analysis, but fear of pseudoreplication results in many researchers either using average values across sequences or randomly selecting one call. Unfortunately, either approach greatly reduces the amount of variation used in analysis. Use of a randomly selected single call is probably more biologically relevant than the mean value from the calls in a sequence. As an alternative, repeated measures or nested factors in ANOVA can be used to examine such variation.

Neural networks do not assume independence; consequently, pseudoreplication is not an issue, and individual calls from a sequence can be used. However, in terms of learning about variation between groups (other than individual), it is advisable not to include too many calls from a single individual, because this tends to reduce the general applicability of the results. The output of neural nets is not evaluated on the basis of assumed statistical properties, such as

Table 1. A sampling of features used to describe echolocation calls to illustrate how different authors named, measured, or described these variables. Measurement information reflects our interpretation of information given in the source.

Name of feature	*Abbreviation*	*Measurement*	*Source*[a]
Variables describing duration of call			
Duration	DUR		7
Duration	dur	measured from amplitude waveform	3, 9
Duration		time interval over which signal was at least 12 dB above noise or within 30 dB of maximum waveform amplitude, whichever was greater	6
Duration	Dur	time between start and end of a call	1
Call duration	cd	measured from amplitude waveform	4
Pulse duration		measured from amplitude waveform or sonogram at –25 dB below maximal amplitude	8
Pulse duration	PD		2
Variables describing time between calls			
Interval	INT	time between successive call beginnings, measured from amplitude waveform	7
Pulse interval	pi	time between start of one call and start of next	4
Pulse interval		measured from amplitude waveform or sonogram at –25 dB below maximal amplitude	8
Interpulse interval	IPI	time from start of one call to start of next	2
Inter pulse interval	IPI	measured from amplitude waveform	9
Inter pulse interval	ipi	end of one call to start of next	3
Time to next call	Next	time from start of current call to start of next	1
Variables describing frequency			
Starting frequency of fundamental	sf	measured from power spectrum, cross checked with sonogram	4
Starting frequency			8
Starting frequency of fundamental	fund start	highest frequency of fundamental calculated by fitting a best-fit mathematical model to sonogram	6
Highest frequency	HFR	search from peak intensity in power spectrum or envelope to highest frequency +6 dB over background in fundamental	7
Highest frequency	hf	peak energy on power spectrum	3
Maximum frequency of fundamental	FMAX		2
Maximum frequency	F_{max}		9

Maximum frequency	Fmax	highest frequency displayed by software	1
Frequency of peak energy in call	MFR	frequency of peak main energy in power spectrum	7
Frequency of most energy of fundamental	FMAXE		2
Peak frequency of fundamental	pf	measured from power spectrum	4
Peak frequency		frequency at which maximum level of sound pressure could be measured from power spectrum	5
Best frequency		measured from power spectrum	8
Terminal frequency of fundamental	tf	measured from power spectrum, cross checked with sonogram	4
Terminal frequency			8
Lowest frequency	lf	measured from power spectrum	3
Lowest frequency of fundamental	LFR	search from peak intensity in power spectrum or envelope to lowest frequency +6 dB over background	7
Minimum frequency of fundamental	FMIN		2
Minimum frequency	F_{min}	measured from sonogram as lowest frequency clearly with more energy than background noise, repeatedly checked from power spectrum and measured at bandwidth –15 dB	9
Minimum frequency	Fmin	lowest frequency displayed by software	1
Ending frequency of fundamental	fund end	lowest frequency of fundamental calculated by fitting a best-fit mathematical model to sonogram	6
Bandwidth	BW_{-15dB}	bandwidth of power spectrum at -15 dB from peak frequency	9
Bandwidth		measured at –30 dB from peak frequency on power spectrum when peak frequency was >40 dB above noise level	5
Bandwidth		starting frequency of fundamental minus ending frequency of fundamental	6
Sweep		range of frequencies in a single harmonic; difference between Fmax and Fmin	1

[a] Sources are: 1 = ANALOOK Software, ver. 4.9g; 2 = Britton et al., 1997; 3 = Fenton et al., 2004; 4 = Kingston et al., 2003; 5 = Kössl et al., 1999; 6 = Masters et al., 1991; 7 = Obrist, 1995; 8 = Siemers and Schnitzler 2000; 9 = Surlykke and Moss, 2000

independence of data, and for that reason does not give probabilities for Type I error. Estimates of error can be obtained by other means, such as randomization methods.

The use of DFA classification functions also does not require independence. The assumption of independence is required only to estimate accuracy rates with the DFA model. Using a technique like sample splitting to determine accuracy rates allows inclusion of multiple calls from a sequence. By using these statistical techniques, the variation present in the analysis can be maximized. However, a classification function that includes varying numbers of calls from individuals most likely will produce a differently weighted function than one built using balanced data. Whether it makes sense to include multiple calls from an individual depends on the goal of the DFA and on the structure of the data presented to the DFA. It is important that we develop methods to measure sequence variation that can be included in statistical tests such as DFA. A single sequence would then become the unit of measure and it would be possible to include a single sequence from each individual, which would preserve the variation without producing misleading results. Researchers using any of these statistical procedures should report sufficient detail to allow a reader to appreciate the significance and limitations of the findings, determine the relative importance of different call parameters, and replicate the analyses.

Openness of the settings in which bats are flying

The impact of the openness of the setting on a bat's echolocation calls is demonstrated by comparing calls recorded as a bat flies in a room with those produced by the same individual flying outside. When bats receive many echoes from nearby objects (e.g., in a room or the confines of a cave or mine), they produce signals that are shorter in duration and broader in bandwidth. Changes in duration reflect the problem of forward masking or self-deafening and the reality that low duty cycle bats apparently cannot broadcast and receive at the same time.

Bat biologists have adopted the term "clutter" (echoes from other than the target of interest) from radar terminology and often refer to the differences between calls obtained from animals flying in the open as opposed to in clutter. Indeed, this distinction can be important, providing useful information about the situation in which a bat is operating and permitting other workers to compare their findings from similar or different situations.

But what do we really mean when we use the term "clutter"? Everyone at the meeting agreed that the term was not well defined, but we are addicted to its use and feel that we know what we mean. In addition to its practical implications for those trying to understand call variation, there are at least two components to clutter. One is the bat's ability to maneuver, and the other is the bat's perceptual field. We need an index of clutter that is scaled to bat size and flight speed (to model the mechanical situation facing the bat) and to the duration and interpulse interval of calls (to model the bat's perceptual field).

Age and geographic variation

Arguments supporting the hypothesis that echolocation calls show geographic variation are confounded by many of the factors mentioned above. Laws et al. (2002) documented geographic variation in calls of *Vespadelus* in Australia. However, Murray et al. (2001) showed that geographic variation was minor in calls of bats from the eastern United States. The challenge is to demonstrate that observed differences are functions of geographic location rather than some other factor, such as differences in habitat, equipment, etc.

Other studies have demonstrated progressive changes in bat vocalizations with age (Jones and Kokurewicz, 1994; Jones and Ransome, 1993; Jones et al., 1992, 1993; Kazial et al., 2001, unpublished data; Masters et al., 1995; Moss, 1988; Moss et al., 1997). Changes include both temporal (e.g., duration, interpulse interval) and spectral (e.g., fundamental frequency, presence of harmonics, distribution of energy across harmonics) features, with most changes apparently completed before young bats begin to fly and feed independently. There also is evidence for colony-specific echolocation calls in *Myotis lucifugus* (Pearl and Fenton 1996) and for individual-specific calls in *Eptesicus fuscus* (Burnett et al., 2001; Kazial et al., 2001; Masters et al., 1991, 1995) and *Otomops martiensseni* (Fenton et al., 2004).

Variation in call features with change in function

Bats with a low duty cycle that produce high-intensity echolocation calls change the features of their calls as they move from searching for, to approaching and attacking a target (prey). Attacks on prey typically are accompanied by "feeding buzzes," characterized by short, broadband calls produced at very short intervals. The progressive shortening and increasing of bandwidth of calls across an attack sequence may reflect a bat's avoidance of self-deafening and pulse-echo overlap, while progressively restricting the volume of space from which the bat obtains detailed information about targets. Higher pulse-repetition rates, as well as shorter, more broadband calls, also have been recorded as bats approach landing sites (landing buzzes) or water surfaces for drinking (drinking buzzes). It seems timely for researchers to examine different buzz situations in more detail. Signals in a feeding buzz are much less variable between species than search-phase calls, perhaps due to convergence in call design or physiological constraints, thus making them less useful in identification.

A variety of species alternate frequencies between adjacent calls (e.g., Kingston et al., 2003). While such alternations appear consistently in the calls of some species (e.g., *Saccopteryx bilineata*—O'Farrell and Miller, 1999), they are variably present in others (e.g., *Molossus molossus*—Kössl et al., 1999). Still other species (e.g., *Barbastella barbastellus*—Denzinger et al., 2001) alter patterns of frequency change over time, as well as frequencies between adjacent calls. In addition, striking patterns of changes in calls across attack sequences have been reported in *Molossus* (e.g., Kössl et al., 1999; O'Farrell and Miller, 1999). The significance of changes in frequency, as well as in pattern of frequency change over time, remains unknown but certainly complicates the identification process.

Influence of other bats on signals of echolocating bats

Recordings of *Tadarida brasiliensis* demonstrate that the range of frequencies in echolocation calls changes in the presence of conspecifics. Similar variation has also been reported from other species, including some vespertilionids (e.g., *Eptesicus fuscus, Euderma maculatum, Lasiurus borealis, Lasiurus cinereus*—Obrist 1995), *Rhinopoma hardwickei* (Habersetzer 1981), and *Tadarida teniotis,* but not from *Taphozous perforatus* (M. B. Fenton, unpublished data). Although groups of feeding bats sometimes include several species, the influence of other species on call features remains unexplored.

When several conspecific individuals are flying together, social calls often are intermixed with what appear to be echolocation calls. Although this suggests separation of function between social and echolocation calls, echolocation calls may also serve a social (communication) function (Fenton, 1985; Masters et al., 1995). To determine whether echolocation calls serve multiple purposes, we need to develop ways to assess changes in echolocation (and other) calls when several bats are flying together. Analysis protocols permitting individual identification of bats by their voice or three-dimensional tracking of bats would be of great use for this endeavor.

Species Identification

Automated identification of bat species using calls recorded in the field is unlikely to be effective when calls are highly variable, until this variability is understood and accounted for. In addition, automated identification likely will be most effective when used with distinctive subsets of call data. When the question is simply whether or not a species is present, rejecting many calls because they are not identifiable to species may not pose a serious problem, assuming that species are equally likely to be excluded. On the other hand, in studies designed to monitor relative patterns of activity, presence of a high proportion of unidentifiable calls may confound statistical analyses by masking true patterns of activity. This will be particularly true if some species are more susceptible to exclusion, for instance by producing highly variable calls. Another confounding factor is that some calls may be difficult to record, either because they are faint (e.g., feeding buzzes or calls of low-intensity bats) or because they are rarely encountered (e.g., some social calls).

Quantifying Bat Activity

Bat activity varies by hour, night, season, and location. In theory, bat activity can be measured by monitoring echolocation calls, although intraspecific differences in intensity of calls make some species (e.g., high-intensity bats) more amenable to this kind of approach than others (e.g., low-intensity or whispering bats). Put simply, high-intensity bats produce more detectable calls than low-intensity species, and we know more about identifying bats from high-intensity calls.

The term "bat pass" has been used to denote the train of echolocation calls produced as a bat flies through the airspace sampled by a detector (Fenton, 1970), but it is clear that a large number of bats active in the same airspace can completely mask trains of pulses associated with individuals. Counting calls is one way to minimize difficulties imposed by high levels of bat traffic, but in some situations, e.g., those involving *Tadarida brasiliensis*, the extremely high number of calls that can be recorded sometimes makes it difficult to distinguish among individual signals, particularly when calls overlap in time. Until more sophisticated analysis programs are developed and verified, automated approaches to counting calls may be most useful when only one species is active and when few calls overlap in time. Using bat detectors in conjunction with infrared video systems may provide data for examining the relationships between number of bats and number of calls detected.

At this time, there is no way to translate levels of acoustic traffic (measured either as bat passes or numbers of calls) into actual counts of bats. The ability to distinguish the echolocation calls of individuals (Brigham et al., 1989; Burnett et al., 2001; Fenton et al., 2004; Kazial et al., 2001; Masters et al., 1991, 1995; Obrist, 1995) ultimately may allow development of an algorithm for converting bat activity to estimates of numbers of individuals. Quantifying activity from large data files remains a challenge, as does the question of how to capture the full range of existing diversity while still subsampling.

Call Libraries

In the United States, two organizations house large libraries of biological sounds, the Borror Laboratory of Bioacoustics at the Ohio State University and the Macaulay Library of Natural Sounds (MLNS) at Cornell University. Neither has yet established an extensive collection of sounds from bats. Other libraries are available from websites (e.g., www.batcalls.org). The current situation means that bat biologists lack an official repository for acoustic data, i.e., one that can preserve records and allow others to validate analyses and conclusions reported in publications based on high-quality recordings.

In Australia, some researchers are suggesting that regulatory agencies insist that anyone using acoustics to identify bats for impact assessments submit examples of the types of calls that they associate with a particular species, with the intent of reducing uncertainty in identification caused by variations in data. Similar concerns exist elsewhere, and the question of call reference libraries was addressed at the annual meeting of the American Society of Mammalogists, in Lubbock, Texas, in June 2003.

Call and call sequence libraries could offer important resources for those studying vocalizations of bats. Libraries will be most useful if they also include copious supplementary information about the recording, such as name of collector, equipment used, date, time, location, type of habitat, presence or absence of other species, accompanying visual observations of bats that were recorded, etc. Although repositories of reference calls are valuable, they do not preclude the necessity for good acoustic field guides, which remain to be developed.

Conclusion

The diversity of research questions, combined with the range of available hardware and software, immediately suggests that there is no "best" way of studying echolocation calls. Although there is no optimal approach, there are steps that can be taken to minimize non-biological variation and to improve statistical assessment of data, while highlighting the underlying biological diversity, with a view to understanding such diversity.

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Appendix 1. Participants in the workshop in addition to the authors.

R. Avila-Flores (York University), M. Aytekin (University of Maryland), S. Biscardi (York University), J. Blasko (York University), E. Britzke (Tennessee Tech University), C. Chiu (University of Maryland), C. Corben (corben@hoarybat.com), K. Ghose (University of Maryland), E. Gillam (University of Tennessee), L. Nawojchik (Ohio State University), J. Ratcliffe (University of Toronto), L. Robbins (Southwest Missouri State University), J. Soha (Ohio State University), G. Spanjer (York University), H. ter Hofstede (York University), J. Wernet (Ohio State University).

Letters to the Editor

Editor's Note: Unlike technical articles, letters are not peer-reviewed, but they are edited for grammar, style, and clarity. Letters provide an outlet for opinions, speculations, anecdotes, and other interesting observations that, by themselves, may not be sufficient or appropriate for a technical article. Letters should be no longer than two manuscript pages and sent to the Feature Editor.

Possible Twin Birth in the Indian Flying Fox, *Pteropus giganteus*

There is virtually no information about twin births in the Indian flying fox, *Pteropus giganteus giganteus*, and only a single infant for each adult female has been reported by various researchers from India and elsewhere (Bates, P. J. J., and M. L. Harrison, 1997, Bats of the Indian Subcontinent. Harrison Zoological Museum, Sevenoaks, United Kingdom; Moghe, M. A., 1951, Proceedings of the Zoological Society of London, 121:703–721). On 1 May 2003, we were making a regular visit to a roosting site of *Pteropus giganteus* at Rail Sadan (26°16'16"N and 73°00'58"E) near Jodhpur, Rajasthan, India. Most bats, ca. 80 individuals, were clustered on the trunk of a tree (*Pithelocebium dulcae*), with all bats overlapping each other so that only their heads were visible. Eight bats, in contrast, roosted freely on branches of the same tree. Of these eight, three were post-parturient females; two carried single infants, but the third was with the twins.

Both twin infants looked healthy and were attached to either side of the mother's breast in a head-to-head direction. Hind legs of the infants grasped the sides of the mother near her vagina, and their heads were near the mother's neck. When we first saw this family, both infants were clearly visible, and eyes of their mother were closed; however, as soon as she detected our presence, she became alert and wrapped the twins in her wings. Over the next 5–6 minutes, the mother gradually relaxed, and first one then the other infant became visible again, and we continued our observations for almost 2 hours. Although it is possible that the adult may have adopted an infant who had lost its mother, it seems more likely that this was an unusual case of twinning in a pteropodid.

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New Record of the Egyptian Rousette (*Rousettus aegyptiacus*) in Southern Iran

In August 2004, there were complaints of damage by fruit bats to citrus trees near Sisan, Jahrom, Fars Province, southern Iran (53°12'E, 28° 36'N). Because fruit bats are somewhat uncommon in southern Iran (Zohoori, H., 2002, Bat Research News, 43:204), we visited a 5-ha orchard of date palms and citrus trees ca. 35 km west of Jahrom in an attempt to document their presence. We had discussions with the local people and observed many signs of fruit bats such as damaged palms and red-colored droppings on the ground and on the leaves and fruit of citrus trees. Although the local people guided us to a cave, where they claimed to have captured fruit bats, we discovered only *Rhinopoma* spp. We returned to the garden and stayed there for two nights but failed to observe any fruit bats.

After one week, however, a local farmer captured a male fruit bat and sent the specimen to us. We identified it as *Rousettus aegyptiacus arabicus* (see Bergmans, W., 1994, Beaufortia, 44:79–126). Some measurements (in mm) of the specimen are: height of ear, 23.28; length of tail, 21.08; length of hind foot, 17.12; forearm length, 91.22; and occipitonasal length, 44.12. Digital photographs of the specimen are available from the senior author.

This species of fruit bats was first recorded in Iran by D. M. Lay (1967, Fieldiana Zoology, 54:1–282) from near Jahrom in 1962, and its presence was confirmed in the same area in 1968 by A. F. DeBlase (1980, Fieldiana Zoology, new series, 4:1–424). Thus the specimen that we obtained is the first from the Jahrom area in more than 35 years. DeBlase (1980) stated that fruit growers in the region apparently were not aware of the fruit bats' existence there in the 1960s and had no complaints about bats feeding upon or otherwise damaging their crop. Possibly the more extensive cultivation of fruit trees that exists today has resulted in increased consumption of citrus fruit by the fruit bats.

We express our appreciation to Mr. O. Tabiee for transporting the sample Tehran, to Mr. H. Hooshmand and Mr. Isa for capturing the bat sample, and to Mr. M. Sheikh for transportation facilities during field work.

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Abstracts are listed in alphabetical order by first author. Contact information for authors who attended the 34th NASBR follows the abstracts.

Genetic Aspects of the Ecology of Big Brown Bats (*Eptesicus fuscus*) in Fort Collins, Colorado: Preliminary Findings

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Previous genetic studies reported co-occurrence of two mitochondrial DNA (mtDNA) lineages of the big brown bat (*Eptesicus fuscus*) in Fort Collins, Colorado. Results from four maternity colonies sampled suggested that the two lineages, an eastern and a western form, co-occur within colonies and are not segregated in this zone of overlap. This discovery of two divergent mtDNA forms in sympatry has prompted a host of ecological questions regarding possible differences between haplotypes in local distribution, reproduction, behavior and susceptibility to disease. We captured big brown bats at maternity roosts throughout Fort Collins and several locations elsewhere in Colorado and collected wing biopsies for genetic analysis. Sequence analysis of the hypervariable control region of the mitochondrial DNA molecule was employed to determine haplotype of individual bats. Haplotypes were used to evaluate ecological data for litter size, virus variant in bats killed by rabies, regional distributions and composition of colonies and populations within Colorado. Preliminary results of this research will be discussed.

Cooperative Efforts to Assess the Impacts of Wind Turbines on Bats

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Wind has been used to commercially produce energy in North America since the early 1970s and has been considered environmentally friendly, though widespread instances of mortality to birds and bats have been reported. Wind has the ability to generate electricity without many of the environmental impacts associated with other energy sources (air pollution, water pollution, mercury emissions, and greenhouse gas emissions associated with global climate change). But the direct and indirect local impacts of wind energy sites on populations of bats are unknown. Unexpectedly high numbers of bat fatalities reported at wind energy sites on ridge tops in the eastern United States have heightened the urgency to understand problems and identify solutions. The Bats and Wind Energy Cooperative (BWEC) was formed in 2003 by Bat Conservation International (BCI), the U.S. Fish and Wildlife Service, the American Wind Energy Association (AWEA), and the National Renewable Energy Laboratory of the U.S. Department of Energy (NREL). The BWEC is an alliance of state and federal agencies, private industry, academic institutions, and non-governmental organizations interested in cooperating to develop and coordinate research opportunities and identify solutions to prevent or minimize threats to bats posed by wind turbines. The BWEC has established scientific and technical review committees responsible for developing priorities and providing peer-review and technical input to BWEC-sponsored research projects. In 2004, the BWEC initiated field research to 1) determine optimum sampling intervals and methods required to accurately estimate mortality of bats at turbines; 2) correlate daily mortality estimates with characteristics of turbines, weather

conditions, and habitat covariates; and 3) evaluate methods and technologies to assess bat presence, behavior, and interaction with turbines and determine which provide the most reliable information for problem solving. Here, we present an overview of the issues surrounding wind energy development and bats, discuss the development and progress of the BWEC, and present preliminary findings from the 2004 field research project.

Character State Changes and Branching Orders in the Gene Trees for Phyllostomid Bats: Implications to Mode and Tempo of Evolution

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Studies of evolutionary relationships of the New World leaf-nosed bats (Phyllostomidae) based on DNA sequence data from nuclear and mitochondrial genes have resulted in a set of hypotheses that are both statistically robust and strikingly different from previously proposed relationships. This paper focuses on the molecular hypotheses and the implications they have for morphological evolution within Phyllostomidae. For example, only two of the seven subfamilies recognized by Wetterer et al., the Desmodontinae and Stenodermatinae, are monophyletic in the gene trees or are not nested within genera proposed for other subfamilies. Such a radical alteration of branching patterns results in significantly different distributions of morphotypes that are required to recreate the primitive character states giving rise to such diversity as vampires, nectar feeders, and frugivores. Within the gene trees the morphotype similar to *Macrotus* and *Micronycteris* is retained near the origin of the last common ancestor of all major radiations. We interpret this as evidence for the omnivorous strategy typical of *Macrotus* and *Micronycteris* being the archetype of all of the diversity present in Phyllostomid bats. It is also important to note that modern day examples of this archetype continue to exist in an array of ecological situations and in distantly related clades. Within this context, the vampires, omnivores, nectivores, and frugivores have radiated as end points rather than intermediate stages that ultimately evolved into another more altered morphological state. Finally, it appears that the last highly derived character state and feeding strategy to evolve was that typical of the Stenodermatinae, which contains more genera and species than any other subfamily of the Phyllostomidae.

Can You Hear Me Now? Timing and Complexity in Tiger Moths' Ultrasonic Response to Bat Attack

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Decades of anecdotal and experimental evidence have revealed that tiger moths are attacked less and survive bat attack more often than similar-sized moths in the night sky. Their good fortune appears to rest upon a pair of sound-producing structures, the tymbals, allowing these moths to cry out when pursued by echolocating bats. These sounds seem to carry the same information that many colorful butterflies transmit to their avian predators, 'Beware of the poisonous chemicals I sequestered as a ravenous caterpillar!' Tiger moth calls may also startle naïve bats and/or jam the bats' biosonar. A two-piece tenet of the jamming hypothesis states that a tiger moth attempting to jam a bat's biosonar should respond late in the echolocation attack sequence to maximize any effects of the proposed disruption and that a moth attempting to warn of its nasty taste should call as early as possible to give the bat time to respond. Other behavioral and neurophysiological work has shown that the more clicks (smallest unit of a tiger moth call) that arrive within a narrow time window before the return of an echo to the bat, the larger the jamming effect. If jamming is a stable strategy, these pieces of evidence predict that the more complex a tiger moth's call, the more clicks produced per unit time, the later in the echolocation attack sequence the moth should click. Here we present evidence from 17 tropical tiger moth species as they respond to playback of a recorded bat echolocation attack sequence. Regardless of call structure, from simple two-click sequences to crescendos of overlapping click trains, the moths respond at the same point in the bat attack. The implications of these findings and alternative hypotheses for the driving force behind tiger moth call complexity are discussed.

Urea Production and Excretion in Bats - The Perils of Extrapolating Allometric Relationships to Low Body Mass

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Based on an allometric analysis, Singer proposed that urea production in mammals increases more than glomerular filtration rate (GFR) with increasing metabolic rate as body size decreases. This hypothesized mismatch between GFR and urea production would elevate plasma urea (Purea) in the smallest mammals because the kidney would be unable to clear sufficient urea to maintain Purea at the low level typical in larger mammals. The allometric equations used to reach this conclusion were based on GFR data from mammals of body mass greater than 100g, on urea production data for humans of varying body mass (approximately 70 kg), and on urea excretion data from mammals ranging in body mass from 20 g to 500 kg. These equations also ignored differences in dietary nitrogen content. No direct measurements of GFR exist for bats of any size, and only indirect measurements of urea production and excretion are available. Nitrogen metabolism in bats with three dietary preferences will be compared to predictions from Singer's analysis. Urea production in bats was estimated from food consumption and nitrogen content of the diet. Insectivores (body mass 7-25 g) produced 65 to 195% of the urea predicted depending on mealworm consumption, while a sanguinavore (body mass 25 g) produced 190 to 1695% of the urea predicted depending on whether plasma or cellular proteins in blood were digested. Urea excretion was estimated from daily urinary urea output. Insectivores (body mass 7-25 g) excreted 166 to 2293% of urea predicted, a sanguinavore (body mass 25g) excreted 908% of urea predicted, and three frugivores (body mass 18.5 to 156 g) excreted 62 to 104% of urea predicted. The insectivores and the sanguinavore had Purea levels between 25-50 mM depending on when food was last consumed, while one of the frugivores had a Purea level of 2.25 mM. Bats with diets high in nitrogen (insects and blood) produced and excreted more urea than predicted by allometry and demonstrated elevated Purea levels, while bats with diets low in nitrogen (fruit) excreted the amount of urea predicted and had a typically low Purea. To accurately extrapolate Singer's allometric relationships for urea production and excretion to low body mass, dietary protein content must be considered as well as body mass.

The Role of Bats as Potential Seed Dispersers of Large-seeded Trees in the Caribbean Lowland Forest of Nicaragua

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Hurricane Joan toppled up to 90% of the rainforest on Nicaragua's Caribbean Coast and up to 50 miles inland. For more than a decade botanists and ecologists have documented the forest's recovery. Factors affecting recovery, re-vegetation, and dispersal of trees that produce large seeds remain unclear. These large seeds do not have mechanisms for dispersal by wind or water, and many characteristics prevent birds and reptiles from dispersing them. The probable dispersers of vital large-seeded trees in this forest must be mammalian, and bats in particular. Mist nets were set along forest trails, at forest exits, and outside of the forest; daytime roost searches and line transects were conducted; and people living and working along the forest were interviewed. Bats appear to be the main potential dispersers of large seeds in this forest. Based on analysis showing that bats may be capable of carrying over 50% of their weight, we determined that bats weighing over 50g were potential dispersers of large seeds – 21.6% of all bats captured exceeded 50g (*Artibeus lituratus*, *A. intermedius*, *A. jamaicensis*). Bat tents with guano and large seed piles were also found within the forest. Large bats were most likely to be caught over pasture or on major trails linking villages. Other small mammals were uncommon, rarely seen, and almost never captured. Bat roosts ranging from a few to hundreds of individuals were located in most hollow trees and in some human structures. Bats that are large enough to disperse large seeds are abundant in the forest, and the occurrence of piles of large seeds associated with bat tents confirms that bats are dispersing large seeds. The discovery that most large bats occurred outside of forested areas may indicate their importance in carrying seeds to deforested areas. This study was intended as a preliminary analysis of the dispersal of large seeds in the rainforest; additional data and more direct studies of seed dispersal are necessary to create a clear account of the role of these bats as dispersers of large-seeded trees.

Censusing Brazilian Free-tailed Bats with Infrared Thermal Imaging -- Challenges, Lessons Learned, and Initial Results

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To census Brazilian free-tailed bats (*Tadarida brasiliensis*) in south-central Texas, we have initiated periodic, non-invasive monitoring of maternity colonies with infrared thermal video cameras. The collection and analysis of these data were challenging because of the topography at the different sites and the enormous numbers and density of emerging bats, as well as the variability of nightly emergence patterns. We describe the lessons learned for future field experiments and discuss the challenges we encountered using our previously-developed semi-automatic censusing algorithms for object recognition and flow rate analysis. We also provide initial censusing results for three major colonies using these methods.

The Five W's of Color Patterns in Bats. Part 2: Who, What, Where, Why and When

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Bats show considerable variation in appearance with respect to pattern and color of pelage. During 2002 -2003, I used museum specimens (Royal Ontario Museum, Toronto) and wild-caught individuals (Belize, Central America, December 2003) to describe, quantify, and categorize the pelage of 400 species of bats. I defined 19 separate pattern types (e.g., dorsal stripe, shoulder epaulettes, etc.), and found that 95 species possessed one or more pattern type (e.g., *Uroderma bilobatum* showed both a dorsal stripe and facial stripes). Each occurrence of one of the 19 pattern types was recorded, giving a total of 113 pattern occurrences over the 95 species. Of these, the most common pattern occurrence (81 cases) was stripes, subdivided into nine categories including ruffs, dorsal/ventral stripes, facial stripes, etc. Spots were the second most prominent pattern type with 24 cases. Three other pattern types (mottled fur, light wing tip, and veined wing) were also recorded. My data were then transformed into a phylogenetic matrix based on 20 characters that included both pattern characteristics and roosting behaviors. This matrix was then mapped onto Jones' et al. bat supertree using Winclada. My data suggest that although there is some phylogenetic component to pelage patterns, roosting behavior appears to be a more accurate predictor of presence or absence of a pattern.

Studies of Long-nosed Bats (*Leptonycteris*) in New Mexico

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The southern long-nosed bat (*Leptonycteris curasoae*) was first captured in New Mexico in 1958 from an abandoned mine in the northern Peloncillo Mountains, near the Arizona state line. Three more individuals were taken from Guadalupe Canyon in the southern Peloncillo Mountains during 1962. The first specimen from the Animas Mountains, 20 km east of the previous records, was taken in 1964. Twenty additional records from the Peloncillo and Animas mountains were known by 1967. All these captures were made between 17 July and 5 October. In 1988, two of the specimens were re-identified as the Mexican long-nosed bat, *L. nivalis*. In 1992 significant new information on the two species was obtained after large numbers (> 150 total) of both species were mist netted during a single night in the Animas Mountains. Subsequent work resulted in the discovery of a nearby day roost and confirmed the temporal pattern observed in earlier records showing that bats occur in the area from mid-July into October. This period coincides with the local blooming of *Agave* spp., a major food source for *Leptonycteris*. In 2002, we initiated studies on these bats in the "bootheel" of New Mexico, funded by the Bureau of Land Management. Our work has focused on surveys of abandoned mines, searches for new roosts, refining our knowledge of distribution and occurrence, and obtaining information on movements and activity patterns of the bats. Internal surveys of over 280 mines in the 1990s revealed no sign of roosting by *Leptonycteris*. We now have examined 217 additional abandoned mine workings, of which 79 provided potential roosting habitat for bats. Fifty-one of these 79 mines contained signs of use by several species of vespertilionid bats. However, no signs of *Leptonycteris* spp. were observed at any of the surveyed workings. In 2003 we began radio-tracking *Leptonycteris* in the Animas Mountains and in 2004 we expanded this aspect of the study. To date, we have placed radio-transmitters on a total of 29 individual bats representing both species. This summer we found one new night roost in the Animas and a new day roost in the Big Hatchet Mountains, over 30 km to the East. Both species appear to be communally occupying both day and night roosts in the area.

On the Distribution of *Ficus sycomorus* and Movements of *Epomophorus* Fruit Bats in Kruger National Park, South Africa

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We mapped the positions of 419 adult *Ficus sycomorus*, sycamore fig trees, throughout Kruger National Park (KNP) by walking or driving along 1,365 kilometers of roads and river courses while logging latitude and longitude of every fig tree encountered into a GPS system. Virtually all *F. sycomorus* trees occurred along the banks of rivers with permanent flow or with groundwater close to the surface. Trees influenced by anthropomorphic event were exceptions to waterside habitats. The densities of sycamore figs along permanently flowing rivers in four transects exceeding 10 km each ranged from 2.2 to 7.6 trees/km. The Shingwedzi River held the highest fig density encountered. The largest rivers of KNP flow west to east. However, a few north to south flowing tributaries, including the Mphongolo, Phugwane, and Shisha tributaries of the Shingwedzi, support populations of sycomore figs. These latter waterways may represent winter feeding corridors that permit epauletted fruit bats (*Epomophorus crypturus* and *E. wahlbergi*) to move between the Shingwedzi and Luvuhu River drainages. Other tree species that are important dietary components of epauletted fruit bats, such as marula, fruit only in the wet (summer) season. We hypothesize that during the dry (winter) season, epauletted fruit bat populations may be isolated within major river drainages that support populations of *F. sycomorus*, whereas these fruit bats may move throughout KNP during the wet season. Between 28 May and 28 June 2004, 12% of the trees surveyed displayed ripe figs. The distribution of trees bearing ripe figs was random among near neighbors within river drainages (Wald-Wolfowitz Runs Test).

The Effects of Water Quality on Bat Foraging Behavior in Stream Ecosystems of the Cape Fear River Basin

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Bats are closely associated with riparian habitat because streams are a source of insects and drinking water. Bats are the top insect predators in these stream ecosystems at night. Two urban streams, North and South Buffalo Creeks, in the headwaters of the Cape Fear River Basin of North Carolina have waste water treatment plants (WWTPs) that release waste water effluent into the streams. Downstream of the WWTP, water is considered impaired because of high levels of waste water effluent-derived nitrogen and fecal coliform bacteria. We tested the hypothesis that impaired water would have an effect on bat foraging behavior. We predicted that bats would forage more often over sites upstream from the WWTP than downstream of the WWTP because of the presumed negative impact of poor water quality on the insect community. We sampled from June - August 2004 using a paired design up- and downstream of each WWTP. A pair of full spectrum bat detectors was used at each site as part of a remote recording unit that was set over night to record bat echolocation in real time and time expanded modes. Call sequences were analyzed using Sonobat and separated into sequences that consisted of only search phase calls (considered commuting) and sequences that contained approach and feeding buzz calls (considered foraging). A total of 32 nights was sampled. Using a preliminary analysis of 20 nights, we recorded a total of 2,268 call sequences upstream from the WWTP with a mean (±SE) of 189±86.4 sequences per night and a total of 1,188 call sequences downstream with a mean of 99.0± 59.4 sequences per night. The difference in total call sequences recorded up- and downstream of the WWTP was not significant ($t_{0.05,\ 11} = 1.3$, p=0.10). There was no significant difference in commuting activity up- and downstream of the WWTP ($t_{0.05,\ 10} = 1.51$, p=0.07), but there were approximately 130 commuting sequences per night upstream versus 30 sequences per night downstream of the WWTP. There was no difference in foraging behavior up- or downstream of the WWTP with respect to the total number of sequences that contained foraging calls ($t_{0.05,\ 11} = 1.19$, p=0.14) or the overall proportion of nightly sequences that involved foraging calls ($t_{0.05,\ 11} = 0.71$, p=0.24). Our preliminary results suggest that water quality has no effect on bat activity. Concurrent studies are linking activity, diet, and insect availability in this watershed.

Winter Roost Site Selection of the Evening Bat (*Nycticeius humeralis*) with Comparisons to Summer Roosting Sites

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We radio-tracked 13 evening bats (*Nycticeius humeralis*) to 34 trees during the summer of 2003, and 11 evening bats to 29 trees during the winters of 2003 and 2004. Males were captured in every month of the year, and we provide capture and radio-telemetry evidence that females are also year-round residents of southwestern Missouri. Evening bats chose trees in late stages of decay during the summer when compared to available trees at two geographic scales, but during the winter they roosted in a higher proportion of live trees. During both the summer and winter, evening bat roosts were located closer to other known roosts than were randomly selected points, indicating a clumped distribution of roosts. Comparisons of summer and winter trees suggest that habitat characteristics, such as surrounding tree density, canopy height, and distance to the nearest water source, are more important than individual tree characteristics in explaining variation between roosts used in the two seasons. Winter roost trees were located in areas with lower canopies and higher densities of trees that would likely cause problems with acoustic clutter during the summer. Roost switching was common during the winter; temperature data taken within tree cavities indicate that this may be due to differences in thermoregulatory properties of large vs. small trees. In addition, we report the use of an underground roost by an adult male evening bat during the winter.

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

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Allen's big-eared bat (*Idionycteris phyllotis*) is one of the rarest North American bat species. Limited information exists about its roosting and foraging habitats. The only currently-occupied known roosts for the desert subspecies (*I. p. hualapaiensis*) are in three mines in the Black Mountains in Mojave County, Arizona. Extensive surveys by the authors in this area since 1998 have failed to discover additional roosts. In August 2004, 0.4 g Holohil transmitters were attached to 12 banded *Idionycteris* (all post-lactating females) that were captured outside the mine (in creosote bush scrub at 1000 meters) as they departed at dusk. 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, equipped with two scanning telemetry receivers connected to antennae on each wing strut. Ground crews were directed to positions from which they could precisely triangulate the bats' positions. The bats traveled approximately 70 km roundtrip nightly between the roost and the foraging areas in the next mountain range to the east. Mesquite grassland and pinyon/juniper woodland were usually present in the higher elevation areas (1500 -2000 meters) where the bats were foraging. 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 in the Cerbat Mountains near the foraging area. The majority of the bats commute a great distance each night from the mine at Union Pass, despite the fact that there are many abandoned mines in the Cerbat Mountain foraging area. By the end of the study, all 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 33 km from the roost, one in pinyon/juniper below a granite cliff and another in scrub oak on the east side of the Cerbats. (This research was supported by an Arizona Game and Fish Department SWG grant, FWS, BLM and AGFD biologists, and the efforts of many volunteers.)

"Finding that 4-star Diner" or How Bats Might 'Anticipate' Productive Foraging Areas

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Insectivorous bats often cope with heterogeneous patches of prey, both temporally and spatially. Research has shown that bats often anticipate productive feeding areas, given their spatial memory and knowledge of the landscape. This paper investigates how rugged canyons in the American southwest can be modeled hydrologically to predict where water will be slowed or impounded by topographic irregularities. These landscapes will affect currents in such a way as to create eddies in the flow. Hypothetically, these hydrologic models might also allow us to evaluate other 'fluids,' such as cold-air drainage, under similar topographic constraints. Because small insects move through air much like swimming through molasses, they may often be at the mercy of these airflow patterns. Insects affected by the fluid nature of air may allow bats to predict where to forage efficiently on patchy food resources.

The Evolution of *Dobsonia* (Pteropodidae). Part II: Further Comparisons Between Morphological and Molecular Patterns

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The genus *Dobsonia* (Palmer, 1898) includes approximately thirteen species that have been distinguished primarily by differences in tooth morphology, body size, and geographic location. I examined the molecular support for these distinctions by reconstructing a phylogeny for the genus using mitochondrial cytochrome *b* gene sequences. I present here an expanded molecular phylogeny for the genus that builds upon the preliminary results I presented last year, and phylogenetically informed analyses of morphological differences and geographic distances among the recovered lineages. The phylogeny employs sequences from >80 individuals including members of nine species and of two subspecies of *D. anderseni* and *D. peroni*, as well as individuals from tow populations of unidentified *Dobsonia*. For *Dobsonia* alone, uncorrected pairwise differences for the 1140 bases of cyt *b* sequence range from 1.4% (*D. anderseni*, *D. moluccensis*) to 10.5% (*D. minor*, most other *Dobsonia* species). Expectedly, most variation occurs in the 3rd codon position, and sequences translated to amino acids show less variation (maximum pairwise difference of 2.9%). The mean transition – transversion ratio is 6.32, with a majority of the transitions occurring between pyrimidines. In most cases, analysis of the cyt *b* sequences easily recovers *Dobsonia* species lineages as they are currently defined. The cyt *b* phylogeny also concurs with Andersen in the uniqueness and basal position of the *D. minor* lineage (small body size, simple premolars and molars); the association of *D. praedatrix* and D. inermis, which are members of Andersen's *D. viridis* group (medium body size, highly complex premolars and molars); and the association of *D. anderseni*, *D. pannietensis* / *remota*, and *D. moluccensis*/*magna* as representatives of the *D. moluccensis* group (large body size, moderately complex premolars and molars). However, Andersen's *D. viridis* and *D. moluccensis* groups do not appear to be monophyletic. For example, individuals identified as *D. peroni*, *D. moluccensis*, and *D. viridis* from islands between Sulawesi and New Guinea show very little sequence differentiation and together comprise a very well supported clade. In this case, the basic evolutionary prediction of a positive correlation between morphological differentiation and phylogenetic distance does not hold, although for other clades the correlation is quite strong.

***Ecomorphological Divergence and Ratios of Coexistence in the *Cynopterus brachyotis* Species Complex**

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*** Polly Campbell** received the **Lubee Bat Conservancy Award**

How do ecologically similar species coexist in sympatry? We address this question from an ecomorphological perspective, using cranio-dental characters and wing morphology to investigate potential differences in resource use among recently diverged species in the Old World fruit bat genus, *Cynopterus*. Molecular evidence suggests that the genus has undergone a relatively recent radiation in Southeast Asia. Data for this study were collected on the Malay peninsula where four nominal species in the *C. brachyotis* complex are broadly sympatric. *C. sphinx* and *C. brachyotis* Sunda are widespread in suburban and agricultural habitats; *C. horsfieldi* and *C. brachyotis* Forest are common in forest. However, while *C. sphinx* and *C. horsfieldi* cross habitat types, *C. brachyotis* Forest and *C. brachyotis* Sunda are apparently restricted to forest and anthropogenic habitats, respectively. Competition theory predicts that syntopic species should differ more than allopatric species in morphological characters associated with niche utilization. Thus, we expected to find the greatest morphological divergence between the two species pairs sharing the highest levels of syntopy (*C. horsfieldi* plus *C. brachyotis* Forest; *C. sphinx* plus *C. brachyotis* Sunda), and the least divergence in the two allotopic species (*C. brachyotis* Forest and Sunda). Although results of principle component analysis of cranio-dental characters indicate that 81% of interspecific variation is explained by size, ratios of species mean trait values do not exceed 1.26 for *C. horsfieldi* vs. *C. brachyotis* Forest, 1.13 for *C. sphinx* vs. *C. brachyotis* Sunda, 1.11 for *C. brachyotis* Sunda vs. Forest. When the effects of size are removed, differences in characters associated with bite force and gape width are strongly loaded; the distance between *C. horsfieldi* and *C. brachyotis* Forest is substantially reduced, while that between *C. sphinx* and *C. brachyotis* Sunda is not greatly affected. Small but statistically significant differences in flight characters suggest that *C. brachyotis* Forest is better adapted than *C. horsfieldi* to foraging in cluttered environments, while *C. sphinx* is capable of faster more cost efficient flight than *C. brachyotis* Sunda. Overall, the results of this study suggest that, for *C. horsfieldi* and *C. brachyotis* Forest, small differences in size and in microhabitat use may allow these two species to avoid competitive exclusion, while differences in trophic morphology and foraging range may be more important in separating *C. sphinx* and *C. brachyotis* Sunda. The substantial morphological overlap between *C. brachyotis* Sunda and Forest provides a possible explanation for why these two species rarely occur in syntopy.

Cave Selection by Bats in Ankarana, Northern Madagascar

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Several abiotic characteristics of caves appear to influence their use as day roosts for bats in the Réserve Spéciale d'Ankarana, northern Madagascar. Few workers have sought to understand roost site selection in caves in Madagascar. Patterns of selection of day roosts in caves by bats may depend on cave microclimate, cave geomorphology, predation and parasitism risk, properties of the surrounding landscape, and human use of the caves. During the dry seasons of 2003 and 2004 we investigated bat use of 24 caves in Ankarana, an area of karst with over 70 known caves of varied geomorphology. We assessed cave characteristics including cave length, cave complexity, entrance size, aspect, surrounding vegetation, and spatial variation in temperature and relative humidity. We also conducted bat emergence observations using audio and video recordings and bat emergence captures to measure the abundance and richness of species using the caves. Number of bat species using a given cave varied from one to eight out of a suite of 13 species found in caves in the area. We used a multiple regression model to evaluate which factors might influence bat cave roost selection. Results suggest that cave length and other characteristics can strongly influence bat use of caves as day roosts in northern Madagascar.

Using Coalescent Theory to Investigate Population Structure in Caribbean Bats

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Advances in coalescent theory allow biologists to investigate population genetic structure using genetic sequence data. One powerful approach tests the predictions of the hypothesis by modeling population structure, simulating data under this model, and using these data to construct a null distribution. This null distribution is then used to evaluate the significance of a parameter estimated from the actual data. We demonstrate the utility of this approach by exploring population genetic structure in phyllostomid bats (*Ardops nichollsi*, *Brachyphylla cavernarum*, and *Artibeus jamaicensis*) from the northern Lesser Antilles. Our hypothesis is that the island populations are genetically distinct because of a combination of founding events, limited migration, and genetic drift exacerbated by catastrophe-induced fluctuations in population size. The first prediction of this hypothesis, that within each species island populations are monophyletic, was tested with a parametric bootstrap approach. Island monophyly could not be rejected in *Ardops nichollsi* (p=0.718), but could be rejected in *B. cavernarum* (p<0.001) and *Artibeus jamaicensis* (p<0.001). A second prediction, that molecular variance is partitioned among islands, was tested using an AMOVA and was rejected in each species [*Ardops nichollsi* (p=0.697); *B. cavernarum* (p=0.598); *Artibeus jamaicensis* (p=0.763)]. In *B. cavernarum* and *Artibeus jamaicensis*, the admixture in mitochondrial haplotypes from islands separated by over 100 kilometers of ocean can be explained either by inter-island migration or by incomplete lineage sorting of ancestral polymorphism in the source population. As a test of lineage sorting, we used simulations of gene trees within a population tree to suggest that lineage sorting is an unlikely explanation for the observed pattern of non-monophyly in *Artibeus jamaicensis* (pW <0.01; pSE = 0.04), but can not be rejected in *B. cavernarum* (pW =0.81; pSE = 0.79). A conservative interpretation of the molecular data is that island populations of *Artibeus jamaicensis*, while isolated geographically, are not isolated genetically.

***Noninvasive Identification of the Avian Host Species of White-winged Vampire Bats (*Diaemus youngi*) from Fecal Samples**

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*** Gerald Carter** received the ***Bat Research News*** **Award**

Although the feeding behavior of vampire bats on agricultural hosts is well documented, little information exists about their feeding ecology on wildlife. Vampire bats feed on a purely liquid diet, making conventional methods of identifying prey remnants through fecal dissection impossible. Furthermore, the precipitin test, a serological analysis used to determine vampire bat hosts, does not easily facilitate identification of unknown wildlife prey and requires sacrificing the individual. Here I present a noninvasive DNA-based method of determining the wildlife or domestic animal hosts of white-winged vampire bats (*Diaemus youngi*) from fecal samples. I extracted, amplified, and sequenced chicken DNA from feces of captive *D. youngi* fed on a diet of live chicken blood. Highly variable nuclear DNA markers were used to identify the host to species level. Analyses of samples from vampire bats caught in Trinidad are ongoing. This technique can be utilized to determine the wildlife hosts of vampire bats not choosing agricultural or domestic hosts. The development of a noninvasive method of determining the wildlife hosts of *D. youngi* is significant in the evaluation of conservation and management plans for this species, which appears to be declining in numbers in major parts of its range in Trinidad and elsewhere.

Foraging and Roosting Sites for Male Spotted Bats (*Euderma maculatum*) in Northern Arizona

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We attached radio transmitters to four male spotted bats (*Euderma maculatum*) captured at their cave roost site during June 2003. We tracked bats for 13 days to identify roosts, foraging locations, and travel corridors. All tagged bats immediately relocated to different day roosts. New roost sites were in cracks, crevices, or small caves in the upper portions of vertical cliffs along the upper Colorado River (Marble Canyon). Spotted bats also night-roosted – one bat in Marble Canyon, others in pinyon-juniper woodlands up to 20 km away from day roosts. Bats emerged from day roosts ~2030 h each night, foraged for several hours, night-roosted for $\leq$3 h, and returned to day roosts during predawn. Bats spent much of their time foraging in Great Basin desertscrub vegetation. Marble Canyon and adjacent tributaries were used as foraging areas and travel corridors. Total distance traveled nightly for two bats was estimated to be ~80 km each. A maximum flight speed of 54 km/h was estimated for one bat. Previous work in northern Arizona with female spotted bats indicated similar travel distances and flight speeds; however, known roosts for females are >150 km from known male roosts (or ~70 km but with a 1700 m elevation gain/loss). Spotted bats appear to be locally common in northern Arizona and use similar habitat compared with other populations; however, foraging distances are much greater than reported elsewhere in the literature.

Reproductive Biology and Behavior of the Tent-making Bat *Artibeus watsoni*

Gloriana Chaverri, Boston University, Boston, MA

Artibeus watsoni is a small frugivorous bat that roosts in leaves modified into tents. It is common in some regions throughout its range, but it is seldom found in altered habitats. Although some authors suggest that *A. watsoni* has a reproductive pattern similar to other well-known frugivorous Neotropical bats, data are lacking specifically for this species. Moreover, little is known about its social organization and mating strategies. Thus, in order to better understand the reproductive biology of *A. watsoni*, I sampled two populations in southwestern Costa Rica for a period of one year. Each month I captured individuals at their roost and radio-tracked several members of one social group. I also attempted to recapture the marked individuals throughout the year to evaluate group stability. My findings, to date, indicate that females of this species attain sexual maturity at approximately three months of age, and that females exhibit a seasonal bimodal polyestry with a postpartum estrus, followed by a period of sexual inactivity after the second birth. The first birth peak occurs late in the dry season (February through April) and the second birth peak is in the mid-rainy season (June through August). Social groups are typically composed of one to four females and their pups, and a single male. However, because *A. watsoni* exhibits a fission-fusion social structure, composition of these social groups may vary greatly over short periods. Thus, long-term studies coupled with genetic analyses of paternity are required to thoroughly understand the mating strategies of this species.

Results of the Third Annual Bat Blitz Conducted in the Piedmont Region of North Carolina

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The third annual Bat Blitz was held from 1-5 August 2004 in the Uwharrie National Forest and the Pee Dee National Wildlife Refuge in the Piedmont region of North Carolina, an area for which baseline data of bat distribution and abundance are lacking. In total, 47 volunteers from 11 states came from as far as Michigan, California, New Mexico, and Texas to contribute their time, equipment, and expertise to help us understand more about the bats of North Carolina Piedmont. During the Bat Blitz, eleven experienced bat biologists led teams of one to six volunteers to conduct mist net surveys at over 30 sites in three counties. Additionally, each team had standardized kits for collecting tissues, fecal samples, and echolocation reference calls. Overall, 77 bats representing five different species were captured: red (*Lasiurus borealis*), evening (*Nycticeius humeralis*), seminole (*L. seminolus*), big brown (*Eptesicus fuscus*), and eastern pipistrelle (*Pipistrellus subflavus*) bats. We saw evidence, and recorded echolocation calls, of two other species, the Brazilian free-tailed bat (*Tadarida brasiliensis*) and the southeastern myotis (*Myotis austroriparius*). Full spectrum echolocation calls from all seven species were recorded. Tissue, hair, fecal samples, and ectoparasites were collected from the 77 individuals captured. These data will be used for local studies of the effect of water quality on foraging behavior of bats in Piedmont watersheds, as well as for studies on the co-evolution of bats and parasites, the evolutionary relationships of North American bats, and the ecology of migratory bat species. In order to increase public awareness of bat conservation, the media was invited to participate. The Bat Blitz was covered in local and statewide papers, and also featured internationally as a 4-minute CNN television piece ('Next@CNN'). Major monetary and logistic sponsors of the Bat Blitz were the Southeastern Bat Diversity Network (SBDN), Land Trust of Central North Carolina, North Carolina State Museum of Natural Sciences, North Carolina State Parks, University of North Carolina at Greensboro, Clemson University, U.S. Department of Agriculture Forest Service-North Carolina National Forest, and the U.S. Fish and Wildlife Service-Pee Dee National Wildlife Refuge. Based on the success of this and the previous Bat Blitz events, a committee has been formed within the SBDN to oversee future Bat Blitz events.

Economic Value of Pest Control Services by Brazilian Free-tailed Bats in Texas Cotton Production

Cutler J. Cleveland, Margrit Betke, Paula Federico, Jeff D. Frank, Thomas G. Hallam, Jason Horn, Thomas H. Kunz, Juan D. López, Gary F. McCracken, Rodrigo A. Medellín, Arnulfo Moreno-Valdez, Chris G. Sansone, and John K. Westbrook, Boston University, Boston, MA; University of Tennessee, Knoxville, TN; Indigo Systems, Goleta, CA; USDA-ARS, College Station, TX; UNAM, Mexico; Ciudad Universitaria, Mexico; Texas A&M University, College Station, TX

Brazilian free-tailed bats (*Tadarida brasiliensis*) form enormous breeding colonies each summer in large caves in south-central Texas and northern Mexico. Prey of these bats includes several species of adult insects whose larvae are known to be important agricultural pests, including the corn earworm or bollworm (*Helicoverpa zea*). We estimate the value of the bats in controlling this pest in cotton production for an eight county region in south-central Texas. We estimate the avoided damage at $741,000 per year, with a range of $121,000 to $1,725,000, compared to a $6 million per year annual cotton harvest.

The Effects of Post-fire Forest Regeneration on Bat Activity in the Sierra Nevada

Walter H. Clevenger, Matina C. Kalcounis-Rüppell, Winston C. Lancaster, California State University Sacramento, Sacramento, CA; University of North Carolina Greensboro, Greensboro, NC

We used acoustic monitoring and mist netting to study the differences in bat activity between an area of coniferous forest regenerating after a forest fire and a controlled area of unburned forest. We tested the null hypothesis that there would be no difference between bat activity within the burned and unburned areas. Our alternate hypothesis was that the level of bat activity within the burned area would be lower than in the unburned area because the forest fire resulted in the mortality or removal of trees used as roosting habitat by bats and plants used as food resources by insects. We used Anabat II ultrasonic bat detectors with sound activated recording devices as well as mist net captures to determine the differences in bat activity levels resulting from the 2001 Star Fire that burned 17,500 acres (7,100 hectares) on the Tahoe National Forest in the Central Sierra Nevada, California. Acoustic monitoring was conducted over 25 nights between May and October 2003. Bat detector units were set randomly during each survey night, with two placed in the burned area and two placed in corresponding unburned areas. Ten nights were supplemented by mist netting for positive identification of bat species present as well as recording reference calls. To monitor bat prey abundance, insect traps were used with captured insects identified to Order. Anabat6 data analysis software was used to analyze the acoustic data by comparing sonograms of unknown commuting and foraging bats with known reference calls from the literature and web-based sources. For the purpose of data analysis, a bat pass was defined as a recorded echolocation call sequence with duration greater than 0.5 seconds consisting of more than two individual calls. To assess the effects of burned versus unburned forest areas, a Student's t test was used. Preliminary data analysis of eight sample nights (total $n = 16$) shows the average level of bat activity in the burned areas was significantly lower than in the unburned area ($t = 2.593$, $p<0.05$). This study is one of the first to examine the direct impact of forest regeneration after fire on bat activity.

Estimating Positions of Bats Using a Synchronized Array of Detectors
Chris Corben, Kim Livengood, Ronald Drobney, and Richard Clawson, U.S.G.S., University of Missouri, Columbia, MO; Missouri Department of Conservation, Columbia, MO

As part of a project to determine call intensities of wild bats, we need to know location of the bat when it emitted a signal. As long as a single call can be recorded by four or more detectors, it is possible to analyze differences in time-of-arrival of the signal to produce an estimate of the bat's position. Hence, we have developed specialized hardware and software to implement a synchronized array of Anabat detectors. Many factors influence the accuracy of a position estimated using this approach. Determination of signal arrival time is of critical importance, but is affected by how the frequency of the call changes in time and by Doppler shifts resulting from the bat's motion. Other factors affecting position accuracy are: the precision with which the detector's positions are known, variation in the speed of sound, and the extent to which the sound is refracted by gradients in atmospheric conditions. Finally, the placement of the detectors will critically affect the volume of space in which a given accuracy is achievable. We report on the effectiveness of a prototype synchronized array, and on efforts to empirically calibrate and test it with signals from a statically mounted ultrasonic source.

Food habits of the Mexican Free-tailed Bat *Tadarida brasiliensis mexicana* (Saussure, 1860) in Nuevo Leon, Mexico
A. Nelly Correa-Sandoval, Arnulfo Moreno-Valdéz, Carlos Hernández-Cienfuegos, Luis O. Tejada, Fabián Lozano-García, Instituto Tecnológico de Cd. Victoria, Tamaulipas, México

The Mexican free-tailed bat (MFTB) is a migratory species that feeds on insects. Moths and beetles are an important part of MFTB diet throughout the summer in Texas. However, no data are available from the southern part of the species distribution range. We are conducting a study of the MFTB diet in a winter roost (Cueva Tio Bartolo) and a spring-summer roost (Cueva la Boca). Guano samples were obtained during the winter season, and stomach contents were obtained during the spring and summer. Preliminary analysis shows that MFTB feed on Cicadellidae, Lampyridae, Noctuidae, Muscidae, Pentatomidae and Scarabaidae in spring. This is relevant because Cicadellidae are important disease vectors of valuable crops like citrus. Pentatomid bugs also affect citrus and other crops in this region. We are conducting further sampling to complete the annual cycle.

Experimental Aerosol Rabies Transmission in Bats
April D. Davis, Richard A. Bowen, and Robert J. Rudd, Colorado State University, CO; New York State Department of Health, NY

Aerosol transmission of rabies virus has been rarely documented but suggested in several cases of rabies, both in animals and humans. The rabies variant implicated in two "documented" cases was the variant found to infect *Tadarida brasiliensis*. However, all documented cases have alternative explanations; consequently, more research is necessary to elucidate the potential of aerosolized infectious rabies virus to induce immune responses or clinical disease in animals. We exposed seronegative *Eptesicus fuscus*, *Tadarida brasiliensis*, and *Mus musculus* to either *Lasionycteris noctivagans*, *Tadarida brasiliensis*, or *Eptesicus fuscus* rabies virus variants. Cell cultures were exposed to each bat virus variant to determine their susceptibility and the infectivity of each virus when delivered by aerosol. Exposed bats continue to remain healthy at 6 months post-exposure and have uniformly developed high levels of rabies viral neutralizing antibodies. Our cell culture results indicate the *T. brasiliensis* variant is more stable in aerosol. One mouse from each *L. noctivagans* and *E. fuscus* group and two from the *T. brasiliensis* group died between ten days and three weeks post-exposure. These results suggest that bats are readily immunized but apparently not highly susceptible to aerosolized rabies virus, whereas mice appear to be more susceptible. We suggest that aerosol exposure in nature may result in seroconversion, thus decreasing the number of bats capable of transmitting rabies virus.

Assessment of Bat Activity at a Proposed Wind Farm Site in Prince Edward County, Ontario

Christina Davy, Jen Blasko, Erin Fraser, and Elisabeth van Stam, University of Western, London, ON

Although mortality of bats at wind energy sites has not been exhaustively researched, there is evidence of high mortality at some sites. The purpose of this study was to document levels of bat activity around a proposed wind farm site in eastern Ontario. We conducted acoustic sampling over two week-long periods, the first in May, and the second in August 2004. We made 5-minute recordings at 1 km intervals along a transect radiating outwards from the proposed site along roads, and established a recording station on the proposed site to monitor activity over evenings and nights in a week. We recorded levels of bat activity (bat passes per min), and where possible, identified species by their calls. We recorded *Myotis lucifugus*, *M. leibii*, *Lasiurus cinereus*, and *L. borealis* in both May and August. *Pipistrellus subflavus* was recorded in August. It is not currently possible to separate the calls of *Eptesicus fuscus* and *Lasionycteris noctivagans*, but one or both were recorded. The presence of two migratory species (*Lasiurus cinereus* and *L. borealis*) in both May and August is significant, because it appears to be migrating bats that are involved in the most spectacular bat-turbine collisions. Overall, bat activity appeared to be higher in August than in May, and at least six of the eight bats found in Ontario are present at the site. This study was commissioned by the company responsible for the site, to maximize the chances of an informed decision about the likely impact of the turbines on foraging or migrating bats. Assessing sites beforehand in this way is a positive trend for bats. As more information is collected on the risks that wind farms pose to bats, it will be possible to make progressively more accurate assessments of potential wind farm sites.

Roost Ecology and Mating System of the White-throated Round-eared Bat *Lophostoma silvicolum*

Dina K. N. Dechmann, Elisabeth K. V. Kalko, and Gerald Kerth, University of Zuerich, Switzerland; University of Ulm, Germany; Smithsonian Tropical Research Institute, Panama

A species' mating system is often closely connected with the amount of investment by mating partners into courtship and/or parental care. One form of such investment is the making of shelters, crucial for the reproduction and survival of many animals. In bats, the vast majority of species strongly depends on, but does not make, shelters. The Neotropical *Lophostoma silvicolum* creates and inhabits cavities in active arboreal nests of the termite *Nasutitermes corniger*. The cost of excavating the hard material of the nests is probably high. This implies that these roosts must offer advantages compared to others, such as tree holes, commonly used by other bats. Temperature measurements in cavities of active and dead (=inactive) termite nests and in tree holes occupied by closely related species showed that the temperature in the active termite nests was extremely stable, and 2.1 - 2.8˚C warmer than in the other two types. In order to tie these findings to the mating strategy of *L. silvicolum*, we also investigated this species' mating system. We found a resource-defense polygyny, where single males excavate the nests. However, only nest-males in good physical condition attract females, thereby achieving a high reproductive success (46%). The nests may serve as a cue for females, helping them to choose high-quality males. We propose that the preference of females for males providing roosts with a beneficial microclimate may explain why the making of these unusual roosts has developed in this genus of bats.

Brain Size and Habitat Complexity in Bats: A Comparative Study

Dina K. N. Dechmann and Kamran Safi, University of Zuerich, Zuerich, Switzerland

Vertebrate brains are organized in modules, which process information from sensory inputs selectively. Therefore they are probably under different evolutionary pressures. We investigated the impact of environmental influences on specific brain centers in bats. Using a phylogenetically independent analysis, we first show that wing area in bats (corrected for body size) is related to the guilds that species belong to. Species are assigned to guilds according to their foraging behavior, which is connected to habitat complexity. We subsequently compared wing area, as a surrogate measure for habitat complexity with the size of the whole brain and with regions associated with hearing (INC), olfaction (MOB) and spatial memory (HIP), while controlling for body mass and phylogeny. Total brain size in bats increases with wing area, suggesting that encephalization is related to habitat complexity. Hearing ability is positively correlated with wing area in echolocating bats, as the *a-priori* expectation suggested. However, the non-echolocating Pteropodidae also show a tendency to increase hearing capability as measured by the size of INC. The size of the olfactory brain increases with wing area only in the Pteropodidae suggesting that this clade makes use of olfaction for orientation and/or the localization of food. Larger wing area is linked to a larger spatial memory in all bats. Our results show that morphological and behavioral adaptations related to flight and neuronal capabilities presumably co-evolved under the same ecological pressures.

Looking Inside Bats: Use of High-resolution X-Ray CT Images to Investigate Comparative Morphology of the Wrist

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Phylogenetic relationships among bats remain a topic of ongoing debate because morphological data and molecular data from different genes result in incongruent phylogenetic trees. As part of a long-term project to assemble a large “total evidence” data set for bats, we are seeking to develop new sources of phylogenetically informative morphological data. The wrist has been largely neglected in previous studies of chiropteran morphology because of the tiny size of carpal elements and the difficulty of examining these structures in traditional museum skeletal preparations. However, because bat wrist structure is essential to controlling flight, and styles of flight are variable among and within families, wrist morphology may hold valuable phylogenetic information. In this study, specimens representing 20 species from 18 extant Chiropteran families were analyzed using images created with high-resolution X-ray computed tomography (CT) at the University of Texas CT Lab. Whole alcohol-preserved bats were imaged with no damage to the specimens, which allowed us to include extremely rare bats like *Craseonycteris* in our sample. Three-dimensional reconstructions of the wrist skeleton of each animal were made using CT slices as thin as 21μ, and these were used to produce high-quality movies that allow virtual rotation and cutaways of the wrist. The resulting movies were used to compare wrist

morphology across families. A total of 32 potentially phylogenetically informative characters were identified in these comparisons. These data were analyzed in a parsimony analysis, and were also mapped onto recent morphological and molecular trees derived from larger data sets. Interestingly, we found that our wrist data support a phylogenetic hypothesis that corresponds most closely to recent molecular trees.

Species Diversity and Nested Community Structure of Bats in the Upper Wabash River Basin, Indiana, USA

Joseph E. Duchamp, Robert K. Swihart, and Jeffrey E. Moore, Purdue University, West Lafayette, IN

Species of bat experience local extinctions, while maintaining their overall range. Habitat fragmentation results in a degraded environment that could potentially lead to local extinctions. To investigate this relationship, we regressed species richness and measures of nested community structure against landscape metrics for 27 sampled landscapes throughout the upper Wabash River basin, north-central Indiana. ANABAT detectors recorded bat calls at randomly located sites for three habitat strata: forest, wetland, and grassland habitats. Recorded bat passes were identified to species using a discriminant function analysis that compared recorded calls to a library of known calls of resident species. Nested community values were calculated using the nested temperature calculator. Candidate models were selected using a best subsets procedure in SAS and ranked according to AIC values. Preliminary models of species richness exhibited a positive southern gradient along with a positive relationship to the proximity of wetlands and amount of forest corridors within a landscape. Preliminary models of departures from nested community patterns contained a positive relationship to forest cover and a negative relationship to urban area and urban shape complexity.

Biting Behavior and the Biomechanics of Feeding: A Finite Element Analysis

Elizabeth R. Dumont, Justin Piccirillo, and Ian R. Grosse, University of Massachusetts at Amherst, MA

Fruit-eating bats from the families Phyllostomidae and Pteropodidae exhibit general convergences in cranial morphology and diet. However, field-based studies demonstrate that species with similar skull shapes often use different biting behaviors during feeding. These biting styles vary with respect to the magnitude and type of load (bending or twisting) applied to the skull during feeding. This discrepancy between cranial morphology and feeding behavior raises the question, is there a relationship between biting behavior and skull shape? To answer this question, we compared the magnitude and pattern of stress distribution during typical and atypical biting behaviors in *Artibeus jamaicensis* (F. Phyllostomidae) and *Cynopterus brachyotis* (F. Pteropodidae). These species have skulls of similar shapes but use very different biting styles during feeding. To capture a global view of stress in the skull and facial skeleton during biting, we turned to finite element analysis - a numerical technique that is used routinely by engineers to predict the behavior of physical systems. We developed 3D finite element models with 10-noded tetrahedral elements from 2D micro-CT scans of alcohol-preserved specimens. Muscle forces for the temporalis and masseter were applied to the models and both bite forces and joint reaction forces were solved automatically by constraining the models at the appropriate points. After an initial analysis, muscle forces were adjusted until known bite reaction forces were reproduced. Comparisons between the models of *Artibeus* and *Cynopterus* demonstrate that atypical biting styles result in higher and more widespread stresses than do characteristic biting styles. Despite the general similarities in skull shape between these two species, the subtle differences between them minimize the biomechanical impact of their different biting styles.

Estimating Survival and Transition States of Big Brown Bats (*Eptesicus fuscus*) in Fort Collins, Colorado

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We used passive integrated transponders (PIT tags) and PIT readers to examine the annual survival of big brown bats (*Eptesicus fuscus*) that roosted in maternity colonies in Fort Collins, Colorado. This effort is part of an ongoing research project investigating rabies transmission in commensal bat colonies in an urban setting. We PIT tagged and released more than 4,500 individuals during the summers of 2001-2004, and monitored their presence at up to 31 different buildings using PIT readers. We also captured individuals by hand at these roosts to gather individual measurements and sample blood for evidence of exposure to the rabies virus. We used model selection techniques in Program MARK to obtain maximum likelihood estimates of annual survival and capture probabilities by roost, age class (adult and juvenile females), and serological status. Estimates of apparent survival of female big brown bats varied by roost and age class. Apparent survival (phi) for adults ranged from 0.70 – 0.85 and for juveniles 0.50 – 0.73. Capture probabilities varied by time, but estimates exceeded 0.98 for each interval between years. We will also present an analysis of effect of serological status (positive or negative for exposure to the rabies virus) on annual survival. Movements among and within roosts were frequent. We monitored movement and estimated transitional probabilities using multi-strata models in Program MARK at six different complexes of roosts. We present preliminary estimates of transitions among different roosts within a summer in relation to ambient temperature, date, ectoparasite loads, and reproductive status.

Radio-tracking of the Greater Long-nosed Bat, *Leptonycteris nivalis*, in Big Bend National Park, Texas

Angela E. England, University of New Mexico, Albuquerque, NM

The greater long-nosed bat, *Leptonycteris nivalis*, is federally listed as endangered in the United States and in Mexico. In the summer, adult females and their young migrate north from Mexico to Big Bend National Park in Texas, and to the southwestern corner of New Mexico. Migration is believed to be synchronized with the bloom cycle of agave plants, on which they rely for nectar and pollen. The recovery plan identified the need for locating and protecting roosts and foraging habitat, and determining nightly distances traveled. In 2003, we attached radio-transmitters to 25 *L. nivalis* and tracked nightly movement patterns in the vicinity of the Emory Cave, the only known roost in Texas. Preliminary results of this telemetry effort are presented here.

Monitoring and Evaluating the Results of Bat Protection Efforts

Nicholas J. Ervin, Keidy Guerrero Rusk, John Taylor, and Kathryn Grandison, Southern Utah University, Cedar City, UT

Populations of many bat species may have declined because of a decrease in historical habitat. Recent studies showed that numerous bat species use abandoned mines. The Utah Department of Natural Resources, Division of Oil, Gas and Mining Abandoned Mine

Reclamation Program closes abandoned mines to protect the public from potential hazards. After surveys, abandoned mines with suitable bat habitat are sealed with bat-compatible gates. However, post-gate monitoring studies are necessary to document long-term effects of these techniques for conserving bat populations. This study monitors the effects of bat-compatible gates used in Utah. Long-term objectives include determining daily and seasonal use of mines by bats, and evaluating species composition. Comparison monitoring in two mine areas in southwestern Utah started in 2000. The Silver Reef area mine adits were gated in 1997 and the Tushar Mountain area mine adits were gated at the end of the 2002 field season. We collected bat behavior data with a combination of monitoring techniques (infra red digital video recorders, night vision goggles, and Trail Master event recorders) and determined species identification through mist netting and Anabat acoustic detection. We netted or acoustically recorded eleven of Utah's 18 bat species at these mine entrances. Dominant bat species in the two areas differed: most Townsend's big-eared bats, *Corynorhinus townsendii pallescens*, were found in the Silver Reef area mines, while numbers of the long-legged myotis, *Myotis volans*, dominated the Tushar area mines. Bat behavior changed significantly at gated mines; circling behavior before entering or exiting the mine audits increased. This change in bat behavior happened at all gated mines regardless of bat species or location. However, circling frequency varied seasonally, possibly due to changes in bat species or age structure. Overall bat use significantly decreased in one mine gated with a culvert.

Modeling the Agricultural Pest Control Service Provided by Brazilian Free-tailed Bats (*Tadarida brasiliensis*) in the Winter Garden Region of South Texas

Paula Federico, Cutler Cleveland, A. Nelly Correa-Sandoval, William E. Grant, Thomas G. Hallam, Jason Horn, Thomas H. Kunz, Juan D. López, Gary F. McCracken, Arnulfo Moreno-Valdez, Chris G. Sansone, and John K. Westbrook, University of Tennessee, Knoxville, TN; Boston University, Boston, MA; ITESM, Monterrey, Mexico; Texas A&M University, College Station, TX; USDA-ARS, College Station, TX; Instituto Tecnológico de Cd. Victoria, Tamaulipas, Mexico; Texas A&M University, San Angelo, TX

The diet of Brazilian free-tailed bats (*Tadarida brasiliensis*) in southern Texas during the summer includes significant proportions of major crop pests, such as corn earworm or bollworm (*Helicoverpa zea*) and fall armyworm (*Spodoptera frugiperda*). The significant natural agricultural pest control service that these bats provide has both a direct economic impact and an avoided costs component. We have developed a deterministic mathematical model that describes bat and bollworm population dynamics in cotton crops in southwestern Texas during the summer. It focuses on the direct ecological and economic impact by simulating scenarios such as changes in bat population numbers, including total absence of bats, different patterns of insect migration and pest control strategies. Number and timing of pesticide applications and cotton yield are used as main response variables to analyze the direct economic impact of the bats. At a local scale, the presence of bats in the ecosystem may reduce up to two pesticide applications during the cotton-growing season. Moreover, at a broader scale, the avoided costs may be quantified in terms of the consumption of adult moths by bats, which reduce the emigrating numbers of insects that would next infest crops in northern areas following a cascade effect.

Echolocation and Clutter

M. Brock Fenton, University of Western Ontario, London, ON

Biologists studying echolocation have adopted the term "clutter" from the literature about radar. While commonly used, clutter is rarely defined even though inferences about what constitute "cluttered" and "uncluttered" habitats abound in the literature. I will use data from flying echolocating bats to illustrate one way to quantify the definition of clutter for a bat using echolocation to detect, assess, and track flying prey.

Phylogeography of Three Evolutionary Lineages of West Indian Phyllostomid Bats: Preliminary Observations

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We are currently studying the phylogeography of three evolutionary lineages of West Indian phyllostomid bats, including *Macrotus waterhousii* (an insectivore), *Erophylla sezekorni /bombifrons* (an omnivore/plant-visitor), and *Artibeus jamaicensis* (a frugivore), to determine how ecology, colonization history, and island size influence the evolution of genetic structure. All three species are widespread in the Greater Antilles (including the Cayman Islands and the Bahamas), and two (*Macrotus* and *Artibeus*) also occur on the Mexican mainland. *Erophylla* is an early phyllostomid colonist of the Greater Antilles: based on the fossil record, *Artibeus* is a recent colonist. Predictions we are testing include: 1) island populations contain less genetic variation than mainland populations; 2) genetic variation is positively correlated with island area, and genetic subdivision is positively correlated with degree of island isolation; 3) genetic variation declines with length of residency in the West Indies; and 4) genetic subdivision increases and genetic variation decreases with increasing trophic position. In addition, we are testing the Griffths-Klingener hypothesis, which states that phylogenetic relationships among islands within species will reflect age of residency. Specifically, the phylogenetic topology of *Erophylla* should differ substantially from those of *Macrotus* and *Artibeus* because of different land configurations at times of colonization. Preliminary results support some of the genetic predictions (e.g., lower genetic variation in some island populations) but do not support the G-K hypothesis. *M. waterhousii* appears to be a paraphyletic species.

A Preliminary Survey of Bat Species Richness within Algonquin Provincial Park, Ontario

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One of the largest provincial parks in Ontario, Algonquin Park contains a diversity of habitat and forest types, including hardwood forests, pine forests, and spruce bogs. It has a highly variable history of development, settlement, and logging, and is currently being logged in a controlled manner. Prior to 2004, little was known about the bats in the park, and only the following four species had been identified: *Myotis lucifugus*, *M. septentrionalis*, *Lasiurus cinereus*, and *Lasionycteris noctivagans*. From 04 June to 13 August, 2004, we used captures in mist nets and traps, and monitoring of echolocation calls to survey bats in the park. Using these techniques, we were able to reconfirm three of the previously known species, and to identify four new species for the park. Over 34 sites, and 41 sampling nights, *M. lucifugus*, *M. septentrionalis*, and *M. leibii* were captured and recorded; *Eptesicus fuscus* was captured; and *L. cinereus*, *L. borealis*, and *Pipistrellus subflavus* were recorded.

Survey of the Bats of the Mobile-Tensaw River Delta, Alabama: Preliminary Results
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Relatively little is known about most of the 15 species of bats in Alabama. Especially scarce are data on species occurring in southern Alabama, including the Mobile-Tensaw Delta region. Because there are significant recent acquisitions of tracts of land into the public trust within the Mobile-Tensaw Delta region, it was especially desirable to obtain an accurate biological survey. Objectives were to conduct a field survey, and to use radio-telemetry to determine characteristics of day roosts of the bat fauna. At each collection locality, habitat, species captured, date and time of capture, sex, age, and reproductive condition were recorded for each individual. Mist nets were used to capture bats, abandoned buildings were searched, and specimens were collected at some sites. Preliminary results will be presented.

Higher-level Phylogeny of Chiroptera Based on Direct Optimization of Ten Genes
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Phylogenetic relationships of bats remain controversial despite analyses of increasingly large data sets. Chiropteran monophyly is well established, but other problems have persisted, many the result of apparent contradictions between morphology and DNA-based results. An important conflict concerns microchiropteran monophyly, which is strongly rejected by the molecular grouping of Megachiroptera + Yinochiroptera (Yinpterochiroptera). The latter implies the secondary loss of laryngeal echolocation in megabats or the independent evolution of echolocation in yinochiropterans and yangochiropterans (costly adaptive scenarios). Other problems include the position of certain bat families (principally Nycteridae and Emballonuridae) and the monophyly of some suprageneric groups (Vespertilionoidea, Noctilionoidea, Nataloidea). To address these issues, most molecular researchers have relied strongly on Maximum Likelihood and Bayesian techniques. As a consequence, a solid parsimony analysis of higher-level bat relationships based on molecular data is lacking. We conducted an analysis of a large data set comprising published sequences from ten genes, five mitochondrial (12S, t-valine, 16S, ND1 and cyt *b*) and five nuclear genes (ADRA2B, BRCA1, RAG1, RAG2, and vWf). Sequences were assembled for 41 terminals representing all currently recognized bat families. In our sample, sequence completeness varied widely from 12 kbp to just 402 bp in rare species. Eleven eutherian outgroups were included, as well as one marsupial to root the tree. In tree searches we used the direct optimization (DO) approach, which transforms multiple sequence alignment into an optimization problem. DO yields less costly trees than the usual multiple alignment + tree search approach, but at the expense of much longer computation times. Separate DO analyses were conducted for each gene, each main partition (nuclear and mitochondrial), and the total 10-genes dataset. Searches were intensive, with 100 replications followed by tree fusing, ratchet, and iterative-pass swap refinements. All but three genes (ND1, 16S, and RAG1) recovered Chiroptera as monophyletic. Only the cyt *b* supported microchiropteran monophyly, whereas four genes supported Yinpterochiroptera. The remaining genes contradicted both groups or were inconclusive. All analyses placed Nycteridae and Emballonuridae in Yangochiroptera. The nuclear partition supported Yinpterochiroptera, whereas the mitochondrial partition supported a monophyletic Microchiroptera. The 10-genes analysis favored Yinpterochiroptera, but levels of support were very low. From a parsimony perspective, the current Yinpterochiroptera hypothesis is weak and may be easily challenged by non-molecular data that tend to support microbat monophyly and an unreversed acquisition of laryngeal echolocation.

Effects of Social Conditions on the Echolocation of Brazilian Free-tailed Bats: Use of a 4-Microphone Array

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Brazilian free-tailed bats, *Tadarida brasiliensis*, exhibit extensive variability in echolocation call structure. One factor that significantly influences echolocation in this species is the presence of multiple bats in the same airspace. The goal of this research is to better understand the ecological and behavioral basis of this variation associated with social conditions. A 4-microphone array system was used to obtain recordings of free-flying bats in the presence of one or more conspecifics. This system allowed us to recreate the position of each bat within a grid and link changes in call structure with the relative position of each bat. A playback study was used to experimentally test the ability of bats to shift frequency and temporal characteristics of their calls in reference to a known signal. In the future, we plan to couple the 4-microphone array with 3D thermal imaging cameras, allowing us to observe and record bats simultaneously.

Acoustic Monitoring of Bats in Southeast Alaska: Development of the Wireless Sensor Array and Analysis of Prior Recordings

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The most recent and extensive effort to document the occurrence of bats in Alaska confirms that five species inhabit certain parts of the state for at least a portion of the year. However, much remains uncertain about the geographic range, seasonal distribution, and population size and dynamics of these northern bats. This project aims to clarify these uncertainties by building upon that which is already known about bats in Southeast Alaska. Within the next two years, the investigators will develop a robust, sophisticated bat sensor system capable of monitoring bat activity for extended periods of time. This bat detector array will employ a software program capable of automatically identifying bats by their calls. For this component of the study, in addition to the development of the bat detector system, bat calls recorded in Southeast Alaska by D. Parker et al. have been analyzed in order to determine what sounds are likely to be recorded during the bioacoustical monitoring of the region. In particular, the sounds on the tapes were investigated and classified, the different types of identified signals were processed and described using Raven 1.2 Beta, and a preliminary investigation of the parameters that can be used to identify different species of bats in Southeast Alaska by their echolocation calls was conducted. Two factors, duration and frequency of maximum power, were found to be useful in discriminating between sound types. Although measurement and consideration of these factors alone theoretically make automated call identification possible, further statistical analysis may be necessary to ensure more accurate sorting.

Distribution and Habitat Selection in Hawaiian Hoary Bats, *Lasiurus cinereus semotus*

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The Hawaiian hoary bat or ‘ope‘ape‘a (*Lasiurus cinereus semotus*) is federally listed as an endangered species. Occurrence records from the Hawaii Heritage Program plotted on Landsat imagery demonstrate the presence of Hawaiian hoary bats on all the major islands of Hawaii and in a large variety of habitats. Records are distributed from sea level to the summit of Mauna Loa (4,000 m). Fieldwork was initiated in July 2004 on our three year research on habitat selection at the home range and day-roost scales. Intensive monitoring of hoary bat presence and movements using visual observation, bat detectors, mist netting, and radio-telemetry is ongoing with an emphasis along the Hamakua region of eastern Hawaii Island. Closed-canopy forest within riverine gorges were the most predictable habitats for observing Hawaiian hoary bats. A primary study objective includes determining the use of native and non-native tree plantations and orchards by hoary bats. A study application includes developing best practice guidelines for harvesting trees and use of herbicides and insecticides.

Sex and Seasonal Differences in the Echolocation Signals of *Eptesicus fuscus*

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Ultrasound is a widely used acoustical method for social communication, as well as for navigation and foraging. Although bats are well known for their use of ultrasound for the latter functions, there is presently limited evidence for its use in the former function. Studies have investigated the possibility for sex differences in the echolocation calls of bats. However, there are no studies that have explored its use during courtship and mating. We have a captive colony of big brown bats housed in environmental chambers that allow us to alter temperature and photoperiod in order to mimic seasonal changes and induce mating behavior. This offers us a unique opportunity to investigate potential sex and seasonal differences in the echolocation calls of big brown bats. We recorded the echolocation calls of 17 adult female and 16 adult male big brown bats before and during the mating season. For each bat, I recorded a minimum of 200 calls. I averaged those calls for eight variables (duration, h1start, mid and end, h1maxa, tcmax, curvature, and f10ub) to get a single measure of each variable for each bat. These variables were analyzed for seasonal differences, sex differences, and individual distinctiveness. We found that there were significant differences in call characteristics in males and females between seasons. In addition, we found call duration to significantly differ between the sexes in the mating season. These results suggest there may be seasonal alteration in echolocation signals and this alteration might play a role in sex recognition during mating.

Molecular Systematics and Biogeography of the Paleotropical Chiropteran Family Hipposideridae

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The Hipposideridae are a diverse family of Paleotropical bats. It consists of a major and diverse genus, *Hipposideros* (about 50 spp.), and other eight genera with only one or two species each. Little morphological variation among species and genera has hindered attempts of resolving the phylogenetic relationships among members of the family. Cladistic and phenetic methods had produced poor hypotheses at all taxonomic levels. The absence of a well supported phylogeny has hindered the study of the evolutionary patterns and the historical biogeography of this diverse family. In this work I generated nucleotide sequences for the complete mitochondrial gene cytochrome *b*, and for a 900 bp fragment of the exon 28 of the protein coding nuclear gene von Willebrand factor, for about 90 samples that cover most species in the family. Phylogenetic analyses by heuristic searches under maximum likelihood, minimum evolution, and maximum parsimony criteria, and by Bayesian inference, all produced very similar hypotheses with high node support. Resolution at the deep nodes was provided by the slowly-evolving nuclear gene, while cytochrome b provided resolution at the shallow parts of the phylogeny. The hypotheses obtained confirm the validity of the established genera, although contradicts the supra-generic organization proposed by former authors. Species groups defined by Hill within Hipposideros were approximately correct, but failed to separate distinct but symplesiomorphic lineages experiencing morphological stasis, such as the Papuan radiation and the African large forms. The fossil record of Hipposideridae allows to set calibration points in the phylogeny. Hipposideridae split from the common ancestor with Rhinolophidae some 35 mya. Correlations of the geography of the fossil record with molecular clock estimates of branching nodes, point to a Eurasian origin of the family. The only fossils belonging to the lineage of the common ancestor with Rhinolophidae and to other Yinpterochiroptera (Megadermatidae) older than 40 mya are European. This supports the hypothesis of the Eurasian origin, since Africa and Australia were still far from Eurasia by that time. South East Asia and Australasia were colonized probably at the beginning of the Miocene. Australasia had a major role in the evolution of the genus *Hipposideros*, since several modern lineages appeared there for the first time. African *Hipposideros* belong in only two distinct lineages that date from the early Miocene (all large forms allied to *Hipposideros commersoni*) and the mid-Miocene (all small forms allied to *H. caffer*).

Bat Survey Results of Tunnels and Abandoned Mines on the Nevada Test Site, South-central Nevada

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Exit surveys were conducted at approximately 60 sites across the Nevada Test Site (NTS). Sites were active and inactive tunnels built in the mid- to late-1900s or abandoned mine adits and shafts that remain from mining operations conducted during the early 1900s. Techniques used to detect bats at tunnel and mine entrances included direct capture using mist nets, visual observations with night vision goggles, video taping activity using a camera with NightSight technology, and acoustic detectors to record bat vocalizations. Three maternity roosts were discovered during the surveys. Townsend's big-eared bats (*Corynorhinus townsendii*) occurred at all three roosts and fringed myotis (*Myotis thysanodes*) occurred at two of the three roosts. Several day roosts and night roosts/foraging sites were also documented. Bat activity was detected at nearly 90 percent of all sites sampled. Eight species were identified during the surveys: pallid bat (*Antrozous pallidus*), Townsend's big-eared bat, California myotis (*M. californicus*), small-footed myotis (*M. ciliolabrum*), long-eared myotis (*M. evotis*), fringed myotis, long-legged myotis (*M. volans*), and western pipistrelle (*Pipistrellus hesperus*). Abandoned mines and tunnels are important biological resources that provide roosting and foraging habitat for at least eight of the fifteen bat species known to occur on the NTS.

Community and Individual Responses of Brazilian Free-tailed Bats (*Tadarida brasiliensis*) to Avian Predation

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In the Winter Garden area of southwestern Texas, the dispersal of large colonies of *Tadarida brasiliensis* from caves and bridges might be characterized via the events of emergence, column formation and maintenance, sub-flocking, and transport to foraging areas. Although the specific reasons for the formation of a dispersal column are difficult to ascertain, conjectures suggest that the column is a community response to the presence of aerial predators. Within the column, the complex dynamics of the aggregate of individuals appear to be generated by judicious choice of individual flight behaviors. We formulate and analyze an individual-based model of the bat column dynamics (BATOID) with the purpose of investigating if individual bats are minimizing self–exposure to predators. If these two conjectures prove true, *T. brasiliensis* has evolved both a community and an individual response to minimize effects of predation during dispersal to foraging areas. Simulations of BATOID, a 3-D spatial representation of bat dispersal movement that is governed by rules formulated in terms of relative velocities, collision, and boundary phenomena, will be presented.

Roost-site Selection of Rafinesque's Big-eared Bats and Southeastern *Myotis* on a Managed Pine Forest in the Lower Coastal Plain, South Carolina

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Studies regarding roost-site selection of *Corynorhinus rafinesquii* and *Myotis austroriparius* primarily have focused on the use of caves and human-made structures (i.e., bridges, buildings). Our knowledge of tree roost selection by these two species is limited. In summer 2004, we radio-tracked five *C. rafinesquii* and four *M. austroriparius* on 41,365 ha of managed pine forest owned by the MeadWestvaco Corporation located in Charleston, Colleton, and Dorchester Counties, South Carolina. Both species selected hardwood trees with multiple cavities, including basal openings. Tree roosts of female *C. rafinesquii* were located over standing water in bottomland hardwood stands adjacent to the Edisto River. Male *C. rafinesquii* and *M. austroriparius* roosts occurred in more upland sites. Males of both species were solitary roosters, whereas females roosted colonially. Data were collected on roost structures (e.g., species, dbh, height) and compared to random stand-level structures. In addition, habitat variables (e.g., basal area, species diversity) and landscape variables (e.g., distance to edge, distance to water) were collected and compared between roost and random sites.

Why are There No Flightless Bats?

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To illustrate the high frequency with which flightless forms have appeared, Steadman has argued that flightlessness may have appeared as many as 2000 times in the fossil record of the South Pacific alone. Within the Order Chiroptera, however, no examples of flightlessness are noted, nor are there apparent instances of a tendency to be flightless in the fossil record. The evolution of bats has been spectacular, resulting in over 1000 known extant species distributed around the globe. All bats are distinguished from other mammals by powered flight, a form of aerial locomotion. In contrast, within the Class Aves, numerous examples exist of a return to flightlessness, considered a directional selection that is correlated with several factors. These factors might include distribution on islands without mammalian predators, or existence on islands without significant competition for resources. Additionally, the maintenance of flight muscles, which may represent up to 17% of body mass, might be negatively impacted by the reduced energetic demand that accompanies a diminution of the flight muscles. Flightless conditions have evolved in aquatic birds (including wing-propelled and foot-propelled swimmers) and terrestrial forms including the rails. Is this due to biogeographic factors, or simply due to mechanical constraints? Could the lack of flightlessness in bats be due to lower numbers of species of bats relative to birds? Coupling of the forelimbs (wings) and hindlimbs is presented as a main factor preventing the assumption of a flightless condition in bats, and examples of bats that are known to be agile on the terrestrial substrate are presented. Although birds have successfully "un-coupled" the wings and the hindlimbs within the development of a suitable airframe, bats have utilized the attachment of the plagiopatagium to the hindlimb or foot to facilitate flight. Although permitting skillful flight, this coupling of the wing to the hindlimb and associated skeletal rearrangements may be the major determinants of the relatively poor terrestrial locomotion of most bats.

Computer Vision for Tracking Bats in Infrared Thermal Video: A Tool for Understanding the Behavior of Bats in Flight

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We recorded the nightly activity of Brazilian free-tailed bats (*Tadarida brasiliensis*) with an infrared thermal camera and developed a method to follow the flight paths of individual bats appearing in the video. Our method builds upon previous work to automatically analyze infrared thermal images of emerging, foraging, and returning bats. It utilizes predictive search and geometrical resolution techniques. With this method, the paths of individual bats can be followed when they change direction and speed, and when bats appear in moderately dense groups. This tracking method promises to expand our ability to better understand the movements, interactions, and group dynamics of bats in flight, including flight patterns observed in different species or at different stages of development.

Comparison of Roosting Behavior and Selection of Three Species of Insectivorous Bats in Taiwan

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I used radio-telemetry to study the roosting behavior and selection of *Hipposideros terasensis*, *Scotophilus kuhlii*, and *Myotis formosus* in central Taiwan during May through August 2004. The three species are mainly distributed in the lowland and cultivated land. In total, I tagged 54 adult females: 15 *H. terasensis*, 23 *S. kuhlii*, and 13 *M. formosus*, located and described their roosts. Preliminary results show that the three species exhibited variable range of fidelity to their day roosts and used different types of roost. The radio-tagged *H. terasensis* only used tunnels as day roosts, the *S. kuhlii* roosted beneath the leaves of two species of palm trees and sometimes in buildings, and *M. formosus* roosted in the foliage of up to 15 species of tropical trees as day roosts. The data also showed that *H. terasensis* almost always returned to the same day roosts and used the same roost for more than ten days consecutively. In contrast, *S. kuhlii* and *M. formosus* commonly used more alternative (1-4) day roosts during two weeks, and switched between roosts more frequently, while the frequency of the roost switching and the distance between the alternative roosts were varied among individuals.

Fatty Acid Composition of Adipose Reserves during Hibernation in *Myotis lucifugus*

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Obtaining sufficient and appropriate fuel prior to the onset of hibernation is critical for over-winter survival. In those species examined, fall adipose depots of mammalian hibernators contain substantially higher concentrations of polyunsaturated fatty acids (PUFAs) than the fat stores of homoeothermic mammals. PUFAs presumably enhance membrane and adipose fluidity, making lipid reserves a more readily available fuel source. Laboratory studies in herbivorous rodents suggest that appropriate intake of PUFAs is critical to the onset, depth, and duration of torpor. Yet the effect of PUFA intake on hibernating bats has largely been ignored. Diets of insectivorous bats tend to have lower concentrations of PUFAs than hibernating rodents, suggesting either that the required intake of PUFAs to achieve stable bouts of torpor is lower or that bats preferentially deposit PUFAs over saturated and monounsaturated fatty acids prior to hibernation. To test these ideas, several hibernating *Myotis lucifugus* were collected, euthanized, and fat pads removed at several points during hibernation. Lipids were isolated from white adipose tissue (WAT), trans-esterified, and gas chromatography/mass spectrometry were used to determine fatty acid concentrations. Relative to pre-hibernation lipid reserves of herbivores, the WAT of *M. lucifugus* collected early in hibernation had substantially higher concentrations of 16:1 fatty acids than all species studied to date and lower concentrations of 18:2 and 18:3 fatty acids than most species. These finding suggest that bats may be able to achieve extended bouts of deep torpor while consuming and depositing less PUFAs than herbivorous hibernators. We also examined change in WAT composition for samples collected on three different dates during the hibernation period. WAT concentrations of 18:0 fatty acids were only prominent in those bats collected relatively early in the hibernation period (mid-December; ANOVA: $F_{2,16}$=10.12, p<0.002). WAT collected from bats in late December and mid-February only had trace amounts of 18:0. In contrast, WAT concentrations of 18:1 were significantly higher in mid-February than in mid-December (ANOVA: $F_{2,16}$=5.96, p<0.02). It is likely that an increase in 18:1 is associated with selective utilization of other fatty acids, especially 18:0, while 18:1 is retained in WAT depots. The melting point of 18:1 is higher than that of 18:2 and 18:3. It seems likely that bats either maintain deposits of fatty acids that would experience a phase transition at significantly warmer temperatures than herbivorous hibernators, or that bats employ an alternate strategy to assure that adipose is a readily available source of fuel.

Bats and Wind Turbines: Infrared Analysis of Abundance, Flight Patterns, and Avoidance Behavior

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Although wind power is a renewable energy resource that is rapidly expanding in the United States, we have barely begun to adequately document and explore the tendency of wind turbines to kill bats and birds, particularly during peak migration periods. Although bat and bird mortality have been documented at large and small wind farms, the mechanism by which individuals are killed and the factors that may attract bats to wind turbines are unknown. We hypothesized that the rotating blades of turbines are primarily responsible for bat mortality. We also hypothesized that aviation lighting on turbines may attract bats either directly, or indirectly by attracting prey insects. To test these questions, we captured digital thermal IR video recordings of bats interacting with rotating wind turbines at the 42 turbines of the Mountaineer Wind Energy Center in Davis, West Virginia. To date, five species have been recovered at this site including *Myotis lucifugus*, *Eptesicus fuscus*, *Lasiurus cinereus*, *Lasiurus borealis*, and *Lasionycteris noctivagans*. To document and quantify these interactions and strike events, we recorded 9 hours of radiometric video data nightly at a randomly chosen turbine for 12 nights. During a typical observation period, 50-100 bat passes or fly-bys were observed within the airspace swept by the rotor blades. Avoidance of moving blades and collisions were also observed. Preliminary results suggest that bat mortality is indeed caused by collision with moving blades rather than the stationary components of the towers. Bats appear to engage in pursuit of prey in the turbine airspace, although aggregations of moths and other prey insects were not observed around the towers. Bats do not appear to respond to ultrasound that may be produced by these structures.

Play Behavior in Captive *Pteropus rodricensis*, the Rodrigues Fruit Bat

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Play behavior is rarely observed in bat species, but it has been described in *Pteropus rodricensis*. We observed play wrestle and play chase in both juvenile and adult captive *Pteropus rodricensis*. No play behavior was observed in infants before 130 days of age. Play behavior developed rapidly after this age. In a focal study of one juvenile between 156 – 193 days of age, play was the largest single category of behavior observed. Play bouts were also observed between adults / juveniles and between adults / adults.

Long-term Fidelity of a Population of Indiana Bats (*Myotis sodalis*) to a Home Area

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In 1995, Indiana bats (*Myotis sodalis*) were discovered consistently using a wooded fenceline as a commuting corridor between southern roosting areas and northern foraging sites. Indiana bats were captured along this flyway in 1995, 1996, 1997, 1998, and 2000; the site was not visited in 1999 or in 2001-2003. In May 2004, five Indiana bats were captured along the fenceline shortly after sundown. One female was radio-tracked, and she was followed to two day roosts in the area; one was a tree within 200 m of the original roost tree discovered in 1995, and the other was a tree within a foraging area of this colony that originally was identified in 1998. These observations, along with recoveries of banded individuals reported previously, suggest that this population of Indiana bats has remained loyal to its home area for at least a period of nine years.

Effectiveness of Tiger Moth (Lepidoptera, Arctiidae) Chemical Defenses Against an Insectivorous Bat (*Eptesicus fuscus*)

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Moths of the family Arctiidae (Lepidoptera) have an impressive diversity of chemical, morphological, and behavioral adaptations that contribute to their defense against both vertebrate and invertebrate predators. The effectiveness of these defensive strategies has been tested previously through whole animal feeding bioassays against a variety of predators: arthropods, spiders, frogs, lizards, and especially birds. In all of these studies, arctiids were consumed by the predators less often in relation to other sympatric and less colorful moths. The majority of these studies, however, examined the combined effect of chemical, visual, and behavioral defenses, and the specific palatability of the moths regardless of these other lines of defense remains untested and unresolved. The goal of this study was to investigate the palatability of arctiids to vertebrate predators based entirely on their chemical defense. Immobilized and silenced tiger moths representing 14 different species were presented to captive big brown bats (*Eptesicus fuscus*) and their palatability to the bats was scored. The results showed that tiger moths are not uniformly palatable or unpalatable to big brown bats, rather they span a spectrum of palatability. Some species are readily taken by the bats, while others are consistently rejected. The relative palatability is highly dependent on the nature of the larval food of the moth. The variation in palatability among species may have encouraged another striking aspect of arctiid biology: visual and acoustic, Müllerian or Batesian mimicry.

The Effect of Water Quality on the Riparian Insect Community in the Headwaters of the Cape Fear River Basin in North Carolina

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In watersheds and riparian corridors, the prey base for North American bats is the emergent insects from the water and the insects associated with riparian vegetation. We documented how water quality affects the prey base for bats in the headwaters of the Cape Fear River Basin in North Carolina. The North and South Buffalo Creeks in Guilford Co., North Carolina, are headwaters of the Cape Fear River Basin, and both have waste water effluent-derived nitrogen enrichment downstream of waste water treatment plants (WWTPs). We tested the hypothesis that this enrichment would have an effect on the flying insect community of the stream and associated vegetation. In a paired design, we sampled upstream and downstream of the WWTP on 31 nights from May-July 2004. To sample emergent insects from the streams, we used emergence traps. To sample flying insects associated with the riparian habitat, we used sticky and Malaise traps. Traps were set from two hours before sunset until one hour after sunrise. Insects were immediately frozen and/or stored in ethanol after traps were retrieved. For our analysis, we counted the number of insects per trap per site per night. We identified all captured insects to order, and where possible family, using published keys on insects of the region and using a reference library of insects from the region. Overall, we captured more insects upstream than downstream of the WWTP ($t_{0.05,30}$=2.38, p=0.012). Traps differed in the number of insects captured up- and downstream of the WWTP, but the only significant difference was found with Malaise traps. There was a difference in the distribution of insect orders upstream and downstream of the WWTP: the most abundant insects upstream were Dipterans and Lepidopterans, and the most abundant insects downstream were Homopterans. Other common orders up- and downstream of the WWTP were Coleoptera, Hymenoptera, Trichoptera, and Hemiptera. Our results suggest that the effluent-enriched water has an effect on both the number and type of insects associated with stream ecosystems. The impact of this difference in the insect community on bat predators is concurrently being investigated.

An Appropriate and Stable Subordinal Classification of Bats

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Recent comparative-method and molecular studies have called into question both the classic subordinal division of bats into Megachiroptera vs. Microchiroptera and the infraordinal separation of microchiropterans into Yinochiroptera and Yangochiroptera. Megabats are not necessarily large, nor are microbats uniformly small; some yinochiropterans may be specially related to megachiropterans whilst others are more nearly affiliated with yangochiropterans; and quite apart from the conflict with DNA comparisons, the basis of the microbat dichotomy (movable vs. fused premaxillae) is neither cladistic nor especially parsimonious. We conclude that current appellations - including the neologism Yinpterochiroptera - no longer embody the authors' intended groups or have been so frequently redefined as to be positively misleading. We therefore adopt the new subordinal names Vespertilioniformes Linnaeus, 1758 (for the group including Emballonuridae, Nycteridae, and the yangochiropterans) and Pteropodiformes

Erxleben, 1777 (for the taxon comprising Pteropodidae, Rhinolophidae, Hipposideridae, Megadermatidae, Rhinopomatidae, and Craseonycteridae) epithets that are based strictly on the oldest generic names for included taxa, and are thus virtually impervious to pre-emption or misinterpretation.

***Gender-specific Diet in the Pallid Bat (*Antrozous pallidus*)**

Kate P. Ingram, University of Nevada, Reno, NV

*** Kate Ingram** received the **Basically Bats Wildlife Conservation Society Award**

Previous analyses indicate that the pallid bat (*Antrozous pallidus*) displays sexual dimorphism in morphology that varies with geography. Specifically, at lower elevations and latitudes in the southwestern U.S., males have a larger cranium relative to their dentition than females. Foraging theory suggests that differences in feeding structure may reflect differences in food choice. I, therefore, investigated the hypothesis that the diets of male and female pallid bats occurring in the southwest differ. Diets were analyzed by comparing fecal sample contents of bats from south-central New Mexico. Two elevation/habitat types were sampled: juniper savannah (5350-5800 ft) and juniper/pinon and ponderosa woodland (7000-7700 ft). Insect and arachnid parts were identified to order (and family where possible). Average percent volume of insect and arachnid groups comprising the fecal samples was estimated for males and females, as was the percent frequency of bats eating each food type.

Swimming in Bats

Dave S. Johnston, H. T. Harvey & Associates, San Jose, CA

Whereas different bat species, particularly those from different families, fly with different styles, bat species also swim with different styles. No bats have evolved swimming to the point that they are obligate swimmers. However, like other terrestrial vertebrates, most bat species can swim. I predicted that bat species that forage over watercourses often have anatomical features that facilitate them to leave the water's surface either by becoming airborne to fly again or to swim ashore. Preliminary observations of five species (*Noctilio leporinus*, *Pteronotus personatus*, *Myotis yumanensis*, *Lasiurus ega*, and *Tadarida brasiliensis*) representing four families (Noctilionidae, Mormoopidae, Vespertilionidae, and Molossidae), were conducted for position of wings during swimming, density and thickness of body hair, buoyancy of body in water, and when possible, swimming speed. Two species, *P. personatus* and *L. ega* jumped out of the water from a floating position. Each positioned its wings at narrow angles from the body before pushing into the water with the axial end of the forearm before becoming airborne. *Pteronotus personatus* also swam at the rate of 26.1 cm/sec. with its wings approximately half-way extended, and the lateral body midline at the water's surface. *Myotis yumanensis* swam with its wings almost completely extended and the lateral body midline above the water's surface. *Tadarida brasiliensis* held its wings tightly and close to the body, with the body midline slightly submerged below the water's surface. *Noctilio leporinus* swam at 19.9 cm/sec. with its wings held at about ≤ extended, with nearly all the body submerged and with only the head and a narrow area of the mid-dorsal portion of the back above the water's surface. *Pteronotus personatus*, *M. yumanensis*, and *T. brasiliensis* had dense, erect underfur that trapped air, preventing water penetration. *Lasiurus ega* had flat hair and underfur that repelled water. *Noctilio leporinus* had erect guard hairs that allowed water to come in contact with the body integument, likely drying readily after getting wet. Observations of pallid bats (*Antrozous pallidus*) in water suggest that this species is generally a poor swimmer.

Conservation Priority Hotspots: What Does Phylogenetic Diversity Add?

Kate E. Jones, Wes Sechrest and John L. Gittleman, Columbia University, New York, NY; University of Virginia, Charlottesville, VA

We generated complete geographic, biological, and phylogenetic databases to examine hotspots of biodiversity for bats. Using a Geographic Information System (ArcGIS), we compared global hotspots of phylogenetic diversity (using a dated species-level supertree phylogeny) to those for species richness, morphological, and ecological diversity. We compared the patterns found in bats to other terrestrial mammals and birds. We also examined how bat hotspots complement existing identified hotspots for conservation (e.g., Conservation International's biodiversity hotspots) to see how well bats are represented in current conservation priority setting exercises.

Restoration, Not Just Conservation, of Bat Caves – Need, Methods, and Case Study of a *Myotis sodalis* Hibernaculum

Jim Kennedy, Bat Conservation International, Austin, TX

The Indiana bat (*Myotis sodalis*) is a federally endangered species reliant on very cold Eastern caves. Many historic roosts are no longer suitable because of saltpeter mining, commercial development, and excessive disturbance. Disturbance can be controlled through well-designed gates and other protective measures. However, physical changes to the cave, such as enlarging passageways and modifying entrances, can alter the microclimate inside the cave so that it is no longer suitable for Indiana bats, even with gating. In 1998 Bat Conservation International and the U. S. Fish and Wildlife Service began a long-term project to monitor and better characterize the temperatures and microclimates of some of the most important current and former roosts. This led to the discovery that many of the sites traditionally considered important and protected, were in fact marginal roosts to which the bats retreated when their primary roosts were no longer available or suitable. Further microclimate research in one cave, Saltpetre (Carter County, Kentucky) led to a predictive model of changes in microclimate throughout the cave system and throughout the year. In the summer of 2003, the first modifications to restore former habitat conditions were completed. Potential impacts to public tours and cultural material were considered and accommodated. Continued microclimate monitoring and future bat counts will provide additional data necessary to adjust the initial modifications in order to achieve the desired 3˚C drop in the overall cave temperature.

Harmonic-hopping Drives Divergence in Wallacea's Bats

Tigga Kingston and Stephen J. Rossiter, Boston University, MA; Queen Mary University of London, UK

Horseshoe bats are a diverse Old World family (Rhinolophidae) that have undergone a rapid radiation in the past five million years. They use a predominantly pure-tone echolocation call matched to an auditory fovea to detect the fluttering wings of insect prey. Here we show that three distinct, sympatric size morphs of the large-eared horseshoe bat (*Rhinolophus philippinensis*) echolocate at different harmonics of the same fundamental frequency. We suggest that switching harmonics creates a discontinuity in the bats' perception of available prey that can initiate disruptive selection. Moreover, because call frequency in horseshoe bats plays a dual role in resource acquisition and communication, ecological selection on frequency may lead to assortative mating and ultimately reproductive isolation, regardless of external barriers to gene flow. We show that the morphs have undergone recent genetic divergence, and this process has occurred in parallel more than once.

Difference in Wingloading Associated with Pregnancy between *Myotis evotis* and *Myotis volans*

Jessica Y. Kiser and Rick A. Adams, University of Northern Colorado, Greeley, CO

Bats inhabit and forage in a wide variety of habitats. Where they forage is directly linked to wingloading. Bats with high wingloading usually forage in open areas,. while bats with low wingloading can utilize cluttered habitats. The wingloading of bats can change with growth, such as in juveniles and with gestation in females. Females experience increased wingloading caused by pregnancy. Thus, females that normally utilize cluttered habitats such as dense forests may be excluded because of lower maneuverability. Wingloading of pregnant *Myotis evotis* and *Myotis volans* were compared to determine if there was a difference. Bats were captured using mist nets. The right wing of the bat was photographed, and weight and reproductive status were recorded. Sigma scan plot software was used to measure wing area, and then wingloading was calculated. Kruskal-Wallis test was used to determine if the wingloading of the two species was significantly different. There was a significant difference in wingloading between pregnant *M. evotis* (n=6) and *M. volans* (n=20). The mean wingloading of *M. evotis* was 0.0023 g/mm^2, with wingloading ranging from 0.0020 to 0.0029 g/mm2. The mean wingloading for *M. volans* was 31.5 g/mm^2, with the wingloading ranging from 0.0024 to 0.0042 g/mm^2. There was a 31% change in wingloading throughout the pregnancy in *M. evotis*, while *Myotis volans* had a 43% change in wingloading. The effects of wingloading on foraging ecology will be discussed.

Dynamics of the Corticosterone Stress Response in the Common Fruit-eating Bat (*Artibeus jamaicensis*) in a Panamanian Lowland Rainforest

Stefan M. Klose and Elisabeth K. V. Kalko, Ulm University, Ulm, Germany; Smithsonian Tropical Research Institute, Panama

Life-history theory suggests that organisms protect fitness-relevant components of their life histories best. In tropical birds living a ‘slow’ pace of life characterized by postponed senescence, low adult mortality, and low reproductive success, a stronger endocrine stress response – mediated by the steroid hormone corticosterone (CORT) – has been found than in temperate counterparts. This response potentially represents a trait characteristic for tropical forest species, protecting future reproductive success in long-lived organisms. The few studies available support this idea; however, evidence is scarce. Compared to similar-sized non-flying mammals, bats are long-lived organisms characterized by ‘slow’ life-history traits. In the common fruit-eating bat, *Artibeus jamaicensis*, on Barro Colorado Island (BCI), Panama, adult survival is high compared to subadults and young, whereas reproductive rates and success are low. We therefore hypothesized that reproductively active females should be highly risk-sensitive and show a more rapid and stronger endocrine stress response than any other part of the population. Circulating corticosterone blood plasma levels of 322 free-ranging individuals of *A. jamaicensis* were determined by radioimmunoassay. This included baseline and time-corrected increase rates (IncCORT) under stress. Animals were caught by mist net between March and December, 2003, and an array of biometric and behavioral variables was controlled for. CORT levels were found to double from a baseline of ~15 ng/ml to ~30 ng/ml after stress exposure. IncCORT was ~1 ng/ml/min. However, in pregnant females, levels averaged six times the baselines (CORT: ~85 ng/ml; IncCORT: ~5 ng/ml/min). Embryonic development was positively correlated with CORT and IncCORT response. In reproductively active males, testis volume was negatively correlated with CORT, and the endocrine stress response was depressed when males were reproductively active (~15 vs. 33 ng/ml). In summary, high and rapid CORT responses were observed in pregnant females, suggesting a high stress- and risk-sensitivity, whereas in males reproductive activity coincided with a depressed response to stress. Findings are in accordance with our 'slow life' hypotheses. We propose that the observed responses may contribute to overall fitness; they should be selected for if benefits of CORT-facilitated escapes increase lifetime reproductive success and outweigh lifetime reproductive costs such as adverse effects of a strong endocrine stress response. Provided that high CORT levels are costly, the demands of reproduction may be more easily met in males of our study-species by a suppressing CORT.

Build It and They Will Come: Establishment of a Founder Colony of Brazilian Free-tailed Bats (*Tadarida brasiliensis*) in a Man-made Cave

Thomas Kunz, Margrit Betke, Diane Hirsh, Nickolay Hristov, Edward Lee, Louise Allen, Jonathan Reichard, Margaret Bamberger, and J. David Bamberger, Boston University, Boston, MA; Selah Bamberger Ranch Preserve, Johnson City, TX

Few researchers have had the opportunity to record the establishment of a major founder colony of bats. In this paper, we report the establishment of a founder colony of Brazilian free-tailed bats (*Tadarida brasiliensis*) in a man-made cave (Chiroptorium), an earthen-covered structure that resembles a natural cave developed specifically for free-ranging bats. This unique structure was designed and constructed using concrete, reinforced steel and Gunite, and covered with soil and planted with native grasses for insulation. Construction began in 1997 and was completed in spring 1998. Until recently (August 2003), this structure attracted only small numbers of transient bats in spring and autumn. The arrival of "several thousand" transient *T. brasiliensis* in August 2003, nearly five years after construction was completed, provided evidence that the environmental conditions inside the Chiroptorium and in the surrounding landscape were sufficient to sustain more than a few transient individuals. In summer 2004, a founder maternity colony formed in the Chiroptorium, where young were born and successfully fledged. In early July 2004 (before young bats were able to fly), we censused adults as they emerged from the Chiroptorium using infrared thermal imaging cameras configured to record emerging bats. Computer vision methods, using object recognition algorithms to identify thermal maxima, were used to characterize individual bats during their nightly emergence. The relatively short emergence periods (~ 5 min) recorded on two census events made it practical to employ a manual counting method – using frame-by-frame enumeration of bats in the camera's field of view. These manual counts, based on data collected on 2 and 3 July 2004, were used to validate our automated censusing algorithms (e.g., object recognition combined with flow-rate analysis and individual tracking). Preliminary validation analyses indicate that estimates derived from our automated census methods are consistent with a manual counting method. We expect to use our validated estimate of colony size for this founder group of *T. brasiliensis* as a baseline for assessing the future status of this newly established maternity colony. Stay tuned!

Ectoparasites of Mormoopid Bats on Puerto Rico

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Three species of mormoopid bats live on Puerto Rico (*Mormoops blainvillii*, *Pteronotus quadridens*, and *P. parnellii*), and in 2002, we conducted the first systematic survey of the ectoparasites of these bats. We captured bats as they returned from foraging to Culebrones Cave, within the Mata de Plátano Field Station of Interamerican University, 7 km SW of Arecibo, and systematically examined them for parasites. We examined 20 males and 20 females of both *M. blainvillii* and *P. quadridens*, but only nine *P. parnellii* were captured during the study. Despite living in the same cave, there were consistent differences in the rates and types of infestations among the species of bat. Overall rates of infestation were 100%, 78%, and 48% for *P. parnellii*, *P. quadridens*, and *M. blainvillii*, respectively. The listrophoroid mite *Lawrenceocarpus micropilus* was found on 80% of *P. quadridens*, 44% of *P. parnellii*, and 5% of *M. blainvillii*. Streblid flies (two species), in contrast, occurred on 89% of the *P. parnellii* but were virtually absent from the other bats. *M. blainvillii* was most commonly infested (32%) with chiggers (five species). Thirteen species of ectoparasite have been identified so far.

Milk Composition of Captive *Artibeus jamaicensis* and *Phyllostomus discolor*

Gary G. Kwiecinski, Olav T. Oftedal, and Corey E. Tabit, University of Scranton, Scranton, PA; National Zoological Park, Smithsonian Institution, Washington, DC

We analyzed milk from a captive colony of two phyllostomid bats, *Artibeus jamaicensis* and *Phyllostomus discolor*. The milk collected was from mothers of known stage of lactation (days 4 - 47 postpartum for *A. jamaicensis* and days 7 - 73 postpartum for *P. discolor*). One set of samples was grouped by lactation stage (pooled group) for traditional analyses of dry matter (oven-drying), carbohydrate (phenol-sulfuric acid method), protein (CHN elemental gas analysis; total nitrogen x 6.38), and fat (Roese-Gottlieb extraction). Another set of samples included milk from individuals in which volumes were adequate from all stages of lactation (prime group). For the prime group samples, fat was also estimated from milk carbon [C] content, calculated as:
fat C = total C - (protein C + carbohydrate C). This method allows determination of proximate composition for samples of milk smaller than 50 µl. For *A. jamaicensis*, prime group milk % wet weight averages ± standard deviation were: dry matter 17.44 ± 2.94; carbohydrate 7.06 ± 0.64; protein 3.10 ± 0.69; fat 3.06 ± 1.37 by Roese-Gottlieb and 3.34 ± 2.09 by milk carbon; and energy was 3.20 ± 0.84 kJ/g. For *P. discolor*, prime group milk % wet weight means ± standard deviation were: dry matter 23.87 ± 3.94; carbohydrate 5.12 ± 0.96; protein 5.94 ± 0.93; fat 10.74 ± 3.66 by Roese-Gottlieb and 11.60 ± 4.71 by milk carbon; and energy was 6.40 ± 1.48 kJ/g. *A. jamaicensis* did not display any significant changes in milk proximate composition during lactation suggesting that the rapid weight gain of the young toward the end of lactation is more due to milk volume increases than to composition change. *P. discolor*, however, displayed increases in dry matter, fat, and energy, suggesting that composition change may play a part in the weight gain in *P. discolor*.

Bat Detector Surveys on Fort Knox: Quantitative Classification of Call Sequences
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As part of a larger study to assess impacts of military noise on the endangered Indiana bat (*Myotis sodalis*) and gray bat (*M. grisescens*), acoustic detection was used to characterize bat activity and species presence at potential study locations on Fort Knox, KY. Anabat II detector systems were deployed for passive monitoring at sites along streams, ponds, lakes, and clearings; multiple sites were monitored on most nights. Recorded search-phase echolocation calls were classified to species using a discriminant function approach. Call sequences were subsequently classified to species if a majority of calls in the sequence were classified to a particular species. Detector surveys were conducted on 53 nights, with a total of 31 sites being sampled. Over 10,000 call sequences from 2002-2003 were analyzed for species identification. Initial classification showed a diversity of species (n = 11) utilizing the study area. However, a weakness of discriminant function-based classification is that each call is classified to the "closest match" among *a priori* classes (species), even when the closest match is relatively poor. We are exploring the use of posterior probabilities, based on nearest neighbor or kernel density criteria, to assess quality of classification attempts. We are also assessing logistic regression as an alternative approach for classifying calls. Our evaluation of these alternatives is on-going, and the impacts of different approaches on the classification of call sequences from Fort Knox are presented and discussed.

The Bias of Bat Netting
Alexander B. Lang, Christa D. Weise, Elisabeth K.V. Kalko, and Heinrich Roemer, Karl-Franzens-University, Graz, Austria; University of New Mexico, Albuquerque, NM; University of Ulm, Germany; Smithsonian Tropical Research Institute, Panama City, Panama

Most bat studies, whether on ecology, behavior, natural history, community structure, or sensory ecology, entail the capture of the animals. For the past decades mist netting has been the most commonly used and most effective technique to capture bats. Though mist netting is a common method and the presence of a 'capture-bias' is known through many anecdotal experiences and often discussed, the biases of mist netting are not well understood. Supposedly there are disparate netting biases for different bat species caused by the behavior, foraging strategy, echolocation skills, and spatial memory of the bats, as well as environmental factors such as location of the net, light conditions, precipitation, and wind. Although some species appear to be fairly well sampled by mist netting, others seem to be underrepresented. To date there are no studies addressing the problem of netting biases directly, and for the analysis of mist netting data, assumptions are often based on anecdotal information. This field season we monitored a mist net set in the understory of the tropical forest of Barro Colorado Island (Panama) with an infrared surveillance camera system for the first four hours of the night. In combination with simultaneous ultrasound recordings, we were able to classify approaching bats in different feeding guilds. The bats showed a variety of responses to the nets and only a fragment of the bats were actually caught in the mist net. Most bats that did fly into the net were able to free themselves within seconds or minutes. The results of this study provide adequate data on mist net biases for the understory bat community of Barro Colorado Island, which will make it possible to assess the abundance of bats based upon mist netting data much more accurately. In addition, the study allows us to improve our standardized mist netting procedures to assess tropical bat communities. The probabilities of different bat species being captured in mist nets, as well as the influence of light conditions, netting site, and weather on netting success, will be discussed.

Bats in Motion: Stereo Object Recognition and Trajectory Analysis of Flying Bats
Edward Y. Lee, Margrit Betke, and Thomas H. Kunz, Boston University, Boston, MA

The flight activity of Brazilian free-tailed bats (*Tadarida brasiliensis*) was recorded at 60 Hz with two infrared thermal cameras in a stereoscopic configuration. The use of stereoscopic imaging made it possible to develop a number of tools for image analysis that could not have been applied to data collected with a single camera. In particular, a method was developed to reconstruct flight paths in three dimensions and calculate additional spatial information, such as distances between points in the scene. Flight characteristics such as velocity, acceleration, and turning radius were computed. The methods were tested on stereoscopic data collected from bats emerging from a cave at dusk, foraging over a cotton field, and returning to a cave at dawn from high altitude. Flight characteristics during those activities were then calculated and analyzed. The analytical tools that we developed have the potential to be invaluable for modeling the flight behavior of Brazilian free-tailed bats and their insect prey.

Ecology of Prairie Bats in Alberta: A Landscape Perspective
Cori L. Lausen and Robert M. R. Barclay, University of Calgary, Calgary, AB

This is a synthesis of bat research done in the prairies of Alberta, consisting of five main projects: 1. A description of roosts and thermoregulatory behavior of reproductive *Eptesicus fuscus* roosting in natural rock crevice roosts; 2. A comparison of *E. fuscus* roost in buildings and in rock crevices, examining roost environment and thermoregulatory behaviors; 3. A rock-crevice roost characterization of *Myotis ciliolabrum*, a “species of concern” in Alberta and throughout Canada, together with a comparison to other rock-roosting species; 4. Determining what role rivers play in bat movement/dispersal and how prairie bats deal with their naturally fragmented landscape, by genetically sampling *E. fuscus*, *M. lucifugus*, and *M. ciliolabrum* throughout southern Alberta and north-central Montana; 5. Determining where prairie bats hibernate in Alberta, given that mountain caves are further than most bats are likely to travel. We present findings for all rock roost characterizations and species comparisons. Rock crevice *E. fuscus* selects roosts based on reproductive stage and thermoregulatory requirements. Roost selection preferences differ among species, with *M. ciliolabrum* being the least selective. Bats in buildings experience a three-fold advantage over those in rock-crevices. Preliminary results will be presented for the hibernation and movement projects.

Bat Activity in Relation to Forest Type and Age in the Upper Piedmont and Mountains of South Carolina
Susan C. Loeb and Gary Peters, Southern Research Station, Clemson, SC; Francis Marion/Sumter National Forest, Columbia, SC

In recent years, much of the research on the conservation and management of North American bats has focused on the effects of forest management practices. However, testing the effects of forest management practices on bat populations is often difficult because of the logistical constraints of conducting large-scale experimental studies. An alternative approach is to examine bat activity in relation to forest composition, age, and management history and infer management effects from these correlative data. However, almost all of the studies on the effects of forest management on bats have been conducted in the Pacific Northwest, Canada, or the northeastern U.S. Thus, we examined bat activity in a managed forest in the mountains and upper Piedmont of South Carolina to determine the relationships between summer bat activity and forest type and age class. The study was conducted on the Andrew Pickens District of the Sumter National Forest in northwestern South Carolina during July and August 2003, and from late May through August 2004. Bat activity was recorded using AnabatII bat detectors connected to CF-storage ZCAIMs. Detectors were placed in 91 stands of six forest types (cove hardwood, upland hardwood, Virginia pine, white pine, yellow pine, and mixed pine-hardwood) and three age classes (regeneration, young, and mature). Regeneration stands were < 15 years, young stands were 16-39 years, and mature stands were 50-154 years. Forest types were also grouped into forest classes: hardwood, pine, and mixed. Stands were sampled for 1-2 nights from sunset to sunrise. At least one bat pass was recorded in 64 of the 91 (70.3%) stands and did not differ among forest types or classes. However, activity varied significantly among age classes (χ^2=6.58, *p*=0.04). Bats were more likely to be present in regenerating and mature stands than in young stands. Although the number of passes did not differ significantly among age classes (Kruskal-Wallis χ^2=3.96, *p*=0.14), the number of calls/pass did (χ^2=7.39, *p*=0.25). The number of calls/pass were significantly greater in regenerating and mature stands indicating that these forests may have been used more as foraging sites whereas young sites may be used more as commuting or incidental sites. Our results are similar to studies in other areas of North America that indicate that forest age and its associated structure are more important in determining bat habitat use than forest composition.

Roosting Behavior and Roost Switching in Six Colonies of the Serotine Bat, *Eptesicus serotinus*, in Central Germany

Solveig Lubeley, University of Marburg, Germany

The serotine bat (*Eptesicus serotinus*) is a typical house bat with summer roosts in buildings. Adult females frequently have knowledge of several maternity roosts, which are used alternately during the same season. To determine the extent of such integrated roost systems and to quantify roost-switching behavior in this bat species in an agriculturally dominated lowland area in Hesse, central Germany, six neighboring colonies (four village and two city colonies, 11-109 adult females per colony) were studied employing radio-telemetry, roost exit counts, and the mark-recapture method. Between 1997 and 2002, 77 serotine bats were radio-tracked for a total of 1935 bat days (56 adult females: 1800 days, 21 juveniles: 135 days). All studied maternity colonies made use of a number of adjacent nursery roosts and an even higher number of individual day roosts. Maternity roosts were found within a radius of 150 m and 300 m within the old center of a village or city, respectively, whereas individual roosts were spread out more widely and were occasionally located in neighboring villages at a distance of up to 10 km. The maximum number of day roosts of a single colony was found to be 51, including 15 maternity roosts and 36 individual roosting sites. As an alternative to roosting in different buildings, one city colony similarly used a system of roosts that was concentrated on a single building with 88 separate crevices above windows as roosting sites. Frequent roost switching of tracked individuals and bat colonies (on average every 4.41 and 7.14 days, respectively) occurred throughout the study period between April and October, and was consistent over several consecutive years. At times, several maternity roosts were used simultaneously by sub-groups of the same colony. These results indicate that colonies of serotine bats have developed highly dynamic day-roosting patterns and may be dependent on the availability of an up-to-now underestimated and complex system of alternate roosting sites.

The Advertisement and Territorial Calls of Mexican Free-tailed Bats
Teh-Sheng Ma, Barbara French, and George D. Pollak, University of Texas at Austin, Austin, TX; Bat Conservation International, Austin, TX

Although bats are best known for echolocation, they are also highly social animals that utilize a remarkably rich repertoire of signals for a variety of social interactions. One of the most complex calls of Mexican free tailed bats, *Tadarida brasiliensis*, the advertisement call, is emitted by dominant males to attract females to their harems. Each call contains two main phrases. The first phrase, or chirp, is composed of 3-6 syllables, and the call is initiated with 10-15 chirp repetitions. The chirps are followed by 2-4 repetitions of a trill. The calls are sometimes emitted in conjunction with visual and olfactory displays. At these times, the male rubs portions of his body with the pheromones from his gular gland and urine, and flaps his wings to distribute his “perfume” to the females in the colony while “singing” his advertisement call. The singing of advertisement calls can be influenced by events in the colony. A female that passes close to the territory of a dominant male evokes singing from that male. Moreover, when that male sings, it stimulates other, nearby dominant males to initiate singing their own advertisement calls. Presumably, the males who are recruited to sing do so to compete with other dominant males in the colony. Subordinate males do not emit advertisement calls and do not form harems. Because of their lack of success in attracting females, subordinate males use aggressive strategies to copulate with females. Here we show that the syllables of the advertisement calls emitted by an individual male are strikingly similar from day to day. We also show the types of variations that occur among the syllables emitted by different individuals in the colony. Moreover, we show movies of male singing, which was initiated by the presence of a female, and how the singing prompted in one male by a nearby female induces the chorusing of other dominant males residing in nearby territories. (Supported by NIH grant DC 00268)

The Importance of Cenotes in Structuring Bat Communities in Yucatan, Mexico
M. Cristina MacSwiney, Frank D. Clarke, and Paul A. Racey, University of Aberdeen, Aberdeen, UK

Cenotes (from the Maya word *dzonot*) are water sink holes formed by the dissolution of limestone. In the Yucatan Peninsula, they are the main water sources for plant and animal communities, including humans. Our project is investigating the importance of cenotes for bats. Bat community structure is being compared between forest and pastureland, with and without cenotes. Our hypothesis is that bat community characteristics (species composition, diversity, abundance, and dominance) will differ significantly between sites and seasons. Five ground mist nets, one canopy mist net, and one harp trap are set at each site. Insectivorous species are also monitored with a Pettersson D980 bat detector and BatSound Pro software. Community characteristics were analyzed with Species and Richness Software. During 48 nights we caught 1,739 bats from six families and 24 species grouped into six trophic guilds: aerial insectivore, gleaners, frugivore, nectarivore, sanguivore, and carnivore. Phyllostomids were the most abundant with 16 species. Molossidae, Natalidae, and Emballonuridae had one species each. *Artibeus jamaicensis* was the most abundant species in all habitats. *Desmodus rotundus* was abundant in the cenote in pastureland but was absent in the cenote in forest. All habitats showed lower bat abundance during the dry season (non-parametric Wilcoxon test). The cenote in pastureland was the most diverse habitat (H'=1.5493) and was significantly different from the others investigated (randomization test at 5% Level). Pastureland was the least diverse. Diversity showed no significant difference between seasons, except in forest without cenote (t=3.65; df=60.5; p<0.05). Our results demonstrated that cenotes increase bat diversity in the habitats in which they occur. Further analysis of the echolocation calls will increase the number of insectivorous species recorded at the study sites

*Two Models of Geographic and Ecological Analysis Applied to the Study of the *Uroderma bilobatum* Hybrid Zone in Middle America

Hugo Mantilla-Meluk, Texas Tech University, Lubbock, TX
*** Hugo Mantilla-Meluk** received the **Karl F. Koopman Award**

In order to assess the potential role of geographic and ecological features of the Nicaraguan Depression and the Gulf of Fonseca in the formation and maintenance of the hybrid zone of Peters' tent-making bat (*Uroderma bilobatum*), I used two different geographic model approaches: ArcGIS 8.2 Spatial Analyst and the Genetic Algorithm for Rule-set Prediction (GARP). Maps of geographic and ecological features of the zone and potential distribution maps of *U. bilobatum* were generated and combined to identify the effects of eco-geographic variables on the establishment and maintenance of *U. bilobatum* hybrid zone. The karyologic and genetic information available was highly congruent with the geographic and ecological patterns analyzed. My analyses support the hypothesis that the geographic and ecological history of the region of the Gulf of Fonseca and the Nicaraguan depression may be responsible for the constitution and maintenance of the zone in two different ways: 1) the formation of physical and ecological barriers to the gene flow between the chromosomal parental races and their hybrids, and 2) the presence of different physical and ecological conditions, and their associated differential selective forces on the hybrids and on both parental races. Based on my hypothesized reconstruction of *U. bilobatum* colonization pattern in Central America, I support secondary contact as the most plausible hypothesis of the origin of the hybrid zone of the *U. bilobatum* in Middle America. My results also suggest that selection against parental types is the most suitable mechanism to explain maintenance of the zone.

Bats Along the Big Hole River, Montana: A Second Year of Inventory

Shauna R. Marquardt, Cheryl A. Schmidt, Sarah L. LaMarr, and Mark A. Rumble, Fort Hays State University, Hays, KS; BS BioServ, Inc., Newell, SD; Bureau of Land Management, Butte, MT; U.S.D.A. Forest Service, Rocky Mountain Research Station, Rapid City, SD

We conducted mist net surveys of bats on land administered by the Bureau of Land Management in southwestern Montana in mid- to late July of 2003 and 2004. Mist nets generally were set in riparian areas over streams. Areas of slow-moving water or pools at vehicular crossings as well as a small water tank also served as successful capture locations. Surveys in 2003 were carried out at elevations of 5,800-6,000 feet and yielded a disproportionately greater number of males relative to females captured in mist nets. Of eight species documented in 2003, *Myotis volans* was the only species for which females were captured. In 2004, surveys were primarily conducted at sites at lower elevations to further ascertain species distributions and to attempt to locate female bats. Elevations of sites in 2004 ranged from 4,800-6,000 feet. A total of 48 bats representing seven species were captured, with *M. evotis* being the most frequently captured species overall. Other species captured included, *M. lucifugus*, *Eptesicus fuscus*, *M.*

volans, *Lasiurus cinereus*, *M. ciliolabrum*, and *Lasionycteris noctivagans*. Whereas captures of males again dominated the sample, 10 of the 48 individuals were female. Both males and females were documented for all *Myotis* species. However, no females were captured for *E. fuscus*, *L. cinereus*, or *L. noctivagans*. Female *Myotis* were found at elevations of 5,100-5,800 feet, with the majority being captured from 5,500-5,800 feet. Bats became active around 2140 hours and most captures were during the initial feeding pulse, which lasted from about 2140-2300 hours. Only five individuals (*E. fuscus* and *M. evotis*) were captured after 2330 hours.

Bat Conservation Issues and Research Efforts on Department of Defense Installations

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Although bat conservation has not traditionally been considered a major component of Department of Defense (DOD) natural resource management programs, recent emphasis on ecosystem management has provided opportunities to improve management for many nongame species, including bats, on military lands. A survey of 50 DOD installations conducted in 2000-2001 revealed that approximately 75% of the sample had conducted bat inventories, but there was considerable variation in survey design and sampling intensity. However, several installations have implemented long-term monitoring programs using a variety of survey techniques, and habitat management for bats is now often included in Installation Natural Resource Management Plans. Activities that potentially impact bat populations on installations include military training and testing, base housing and support facilities, forest management, water developments, and fire management. To date, research efforts on military facilities have focused on issues regarding federally listed endangered species, primarily the Indiana bat (*Myotis sodalis*) and gray bat (*M. grisescens*). Current studies sponsored by the U.S. Army are investigating the potential impacts of military noise sources, primarily high-caliber weapons fire, on endangered bats. Increased interest in bat conservation and management among DOD natural resources personnel has resulted in the establishment of a Bat Working Group by the National Military Fish and Wildlife Association (NMFWA). The working group meets in conjunction with NMFWA's annual training session and is responsible for addressing bat issues and sharing information among all DOD natural resources offices. Recent military research projects and activities of the NMFWA Bat Working Group are discussed. Additional information may be found on NMFWA's website: <www.nmfwa.org>.

Fecal DNA Analysis to Identify Species of Insects in the Diets of Bats

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The digestive processes of bats render soft-bodied insects to fragments that, typically, cannot be identified below ordinal level (e.g., Lepidoptera). We demonstrate that species-specific DNA sequences of insects can be amplified by polymerase chain reaction (PCR) from the feces of bats that have eaten those insects. We describe our efforts to utilize a conserved region of the mitochondrial cytochrome oxidase II gene (CO-II) to document consumption by Brazilian free-tailed bats (*Tadarida brasiliensis*) of four noctuid crop pests (Lepidoptera; Noctuidae: *Helicoverpa zea* (corn earworms), *Heliothis virescens* (tobacco budworms), *Spodoptera frugiperda* (fall armyworms), and *S. exigua* (beet armyworms) in an agricultural production region in Texas. Sequence variation at the CO-II gene was characterized in the four noctuid species from adult moths collected in the study area. Target DNA sequences were amplified by PCR from the feces of captive bats that were fed insects in controlled laboratory experiments, and from the feces of wild bats that foraged in the agricultural landscape. We are exploring the use of terminal restriction fragment length polymorphism (TRFLP) analysis of amplified sequences as a potentially efficient method for species-level identification and quantification of prey DNA in bat diets. Our goal is to document the daily and seasonal consumption of pest insect species by bats in relation to the emergence and availability patterns of the insects to assess the services provided by bats in the suppression of insect pest populations.

Flutamide and Fadrazole are Ineffective in Blocking the Expression of Male Mating Behavior in Big Brown Bats

Mary T. Mendonça, Auburn University, Auburn, AL

Male big brown bats mate in late fall and upon arousal from hibernation conditions throughout the winter, a time when testes are regressed and plasma testosterone levels are relatively low. Over the last several years, we have been exploring the relative effects of sex steroids and temperature change on the expression of mating behavior in the big brown bat, *Eptesicus fuscus*. We have found that gonadectomy has little effect on the expression of male mating behavior, whereas exposure to hibernation conditions potentiates the expression of mating upon subsequent arousal from hibernation. To further test the degree to which male mating behavior is influenced by androgens, we conducted a series of experiments in which we administered either flutamide (an anti-androgen), fadrazole (an aromatase inhibitor), or blank Silastic capsules to both gonadectomized and intact males over a period of two weeks and observed their subsequent mating behavior while implanted. In some of the experiments, we then removed the capsules, observed the subsequent behavior, and then re-administered the same treatments. Male mating behavior was not significantly decreased by either flutamide or fadrazole treatment, indicating that male mating behavior in this species is relatively independent of the activational effects of androgens.

Urban Non-reproductive Mixed-sex Clusters of Little Brown Bats (*Myotis lucifugus*)

Jackie D. Metheny and Steven J. Ropski, University of North Carolina at Greensboro, Greensboro, NC; Gannon University, Erie, PA

During the past ten years, bats have been observed on the external surfaces of buildings on the campus of Gannon University in Erie, PA. In this urban setting, little brown bats (*Myotis lucifugus*) roost on surfaces both individually and in small clusters. During the summers of 1994, 1995, 2002, and 2003 data were collected about basic population structure for this species. Approximately three to five days per week for 6 to 22 weeks between 1 May and 14 October, a set route was walked around the campus. Bats that could safely be removed were weighed, tagged (with a forearm band or marked with paint), identified to species, sexed, and had their reproductive status qualitatively assessed. The locations of bats that could not be removed were recorded and tentatively identified to species based on size and color. The average number of clusters per day was 2.5 (0 to 12) with an average of 3.1 bats per cluster (2 to 21). The average number roosting individually per day was 6.7 (0 to 51). Banded individuals were never observed in subsequent study years. During the same season, banded and painted individuals were seen on subsequent days. Based on sightings of 121 marked individuals, bats changed roost sites and roost mates. The sex ratio of banded *M. lucifugus* was 1:1. Females appeared to be non-reproductive in all study years. We found no obvious indications of pregnancy as no mass gain was recorded, and no pups were ever observed. Population numbers increased toward the end of the season, possibly due to the recruitment of juveniles from other roosting areas. This non-reproductive colony of adults, with an equitable sex ratio, appears to be adhering a fission-fusion model of roost behavior within but not between seasons.

Bats in a Fragmented Landscape: Changes in Species Diversity and Structure of Bat Assemblages on Small Land-bridge Islands in Central Panama

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Fragmentation of tropical forests has wide-ranging consequences for wildlife, affecting species richness and composition of many animal assemblages. One key finding that has emerged from fragmentation studies conducted so far is that species' responses to fragmentation are profoundly influenced by the surrounding habitat matrix. Thus, to better understand the effects of fragmentation on forest fauna, it has become increasingly important to examine the influence of matrix type on animal assemblage structure and diversity. In this context, the study of faunal assemblages on land-bridge islands surrounded by a homogeneous aquatic matrix can provide important insights into how species assemblages are affected by habitat fragmentation while controlling for potentially confounding matrix effects. Here we report on preliminary results of an ongoing study on bat species richness and abundance patterns in a fragmented forest landscape in central Panama. Using a combination of mist nets set at ground and canopy level to inventory the bat fauna, we compared assemblages of a set of ten land-bridge islands in Gatun Lake with those at six sites in continuous forest on the nearby mainland. Our results show that these land-bridge islands harbor an impoverished and structurally simplified bat fauna compared to nearby mainland assemblages. Rank-abundance curves for the island assemblages were extremely right-skewed reflecting the dominance of a few frugivorous species, particularly of the Jamaican fruit-eating bat *Artibeus jamaicensis* that made up about two-thirds of all captures. With the exception of the small gleaning insectivore *Micronycteris microtis*, bats of this foraging guild were lacking on almost all the islands except the ones very close to the mainland. We found discernible gradients in species composition that appeared to be largely governed by degree of isolation of the forest remnants from the mainland and habitat heterogeneity. These gradients could, in part, be explained by bat life-history attributes such as foraging guild, body size, home range, and roosting requirements. Our results stress the importance of patch connectivity for the maintenance of a species-rich bat fauna in fragmented landscapes.

Thermoregulation and Arousal Patterns of Hibernating Eastern Red Bats (*Lasiurus borealis*)

Miranda B. Milam, Brad M. Mormann, Lynn W. Robbins, and Thomas E. Tomasi, Southwest Missouri State University, Springfield, MO

Unlike other temperate hibernating bats, eastern red bats (*Lasiurus borealis*) do not utilize the typical hibernacula (e.g., caves, crevices, buildings). Instead, *L. borealis* will move into leaf litter during the cold bouts of winter months and arouse to forage on warm evenings. Because temperatures fluctuate widely at these winter roost sites, the first goal of this study was to discern whether winter arousals are spontaneous or rely on ambient temperatures. If spontaneous, is arousal frequency dependent on ambient temperature? In conjunction with this, we also questioned how stable temperatures are within leaf litter microhabitats. Bats were captured during fall of 2003 in southwest Missouri and kept in captivity during the winter season in environmental chambers simulating natural conditions. Torpor duration was assessed via oxygen consumption rates at 7˚C and 15˚C. Preliminary data suggest that spontaneous arousals occur and are less frequent at lower ambient temperatures. Additionally, leaf litter provided bats with a relatively stable thermal microclimate (compared to widely fluctuating air temperatures in the field). During winter of 2004, we plan to simultaneously record body temperature while exposing a larger sample size to varied ambient temperatures, both in environmental chambers to monitor arousals, and in metabolic chambers to measure metabolic rates. We also intend to analyze these data for differences between the sexes. These studies of thermal limits, in comparison to preferred hibernation temperatures, will give us a better understanding of this species' thermal ecology.

Evening Bat (*Nycticeius humeralis*) Day-roost Selection in Relation to Forest Management in Southwest Georgia

Adam C. Miles, Steven B. Castleberry, Darren A. Miller, and L. Mike Conner, University of Georgia, Athens, GA; Weyerhaeuser Company, Columbus, MS; Joseph W. Jones Ecological Research Center, Newton, GA

The longleaf pine (*Pinus palustris*) ecosystem historically dominated the Coastal Plain of the Southeast. These forests provided excellent opportunities for cavity and bark roosting bats because large trees and snags were abundant throughout the landscape. Natural longleaf pine forests have been drastically reduced, while intensively managed loblolly pine (*Pinus taeda*) plantations have increased in the Southeast. Intensively managed pine plantations have short rotation times (< 30 years), which may limit development of large trees and snags, and therefore could limit opportunities for cavity- and bark-roosting bats. The objective of this study was to investigate the day-roost selection of a cavity- and bark-roosting bat species in both intensively managed and natural pine forests landscapes. We chose the evening bat (*Nycticeius humeralis*) as a focal species because it commonly roosts in cavities or under exfoliating bark, it is frequently captured and is relatively abundant in pine forests of the Southeast, and it has been the focus of only a few studies in this region. We investigated day-roost selection of evening bats on two study sites in the Gulf Coastal Plain of Georgia. The Joseph W. Jones Ecological Research Center, Baker County, Georgia is a second growth mature longleaf pine reserve managed with a two-year fire rotation. The Aultman Tract, Worth County, Georgia is managed by Weyerhaeuser Company for loblolly pine sawtimber and pulpwood production with a 30-year clear-cut rotation. We identified roost trees using radio-telemetry and confirmed a sample of these with dusk emergence counts. We used logistic regression to create roost selection models for each study area by comparing tree, stand, and landscape variables between roost sites and random sites selected throughout each area. From May to August 2002 and 2003, we tracked 100 evening bats to 168 individual roost trees. Bats used a variety of structures, but live conifers (*Pinus* sp. and *Taxodium* sp.) were the most common type of tree used on both study areas. Pine snags, hardwoods, and hardwood snags were also used as roost trees. Multi-scale models provided evidence that roost site selection differed in relation to availability of roost structures across each site. The conservation implications of our roost selection models will be discussed in terms of forest management in the Southeast.

Using Euclidian Distances in Habitat Selection Studies of Bats

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A variety of techniques have been used to document habitat selection by bats, including mist net and ultrasonic detector surveys, and increasingly, use of radio-telemetry. Radio-telemetry data have primarily been interpreted with use vs. availability resource selection techniques. However, it is difficult to achieve precise locations on foraging bats, making misclassification of habitat types a likely problem. Moreover, to date, there are no methods for assessing accuracy of telemetry used to locate foraging bats; thus it is not possible to establish empirical error distributions for telemetry locations. Use of distance techniques solves many sampling and analytical shortcomings of use vs. availability techniques. Our objective is to examine issues associated with habitat selection studies in bats and to demonstrate application of a newly described Euclidean distance approach for measuring habitat selection. This technique does not assign estimated locations to habitat types, but rather uses distances from estimated locations to all available habitat types. These distances are compared to a null model to determine if habitat selection is occurring and to rank habitats in order of preference. Habitat data are analyzed with multivariate analysis of variance (MANOVA), allowing for testing of main effects (e.g., gender, season, year) relative to habitat selection. Additionally, because distances can be measured to landscape features other than habitat blocks (e.g., roads, streams, snags, etc.), more information can potentially be derived from radio-telemetry data. We believe that this technique has many advantages to bat habitat studies that should provide more reliable information on bat habitat selection. We demonstrate this technique using radio-telemetry data collected on bats from a highly fragmented landscape in South Carolina.

Modeling of Traffic Patterns of Bats to Assess Constraints on Population Size

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The question of coexistence in caves was approached through the development of a flow model of the activity of bats that form non-random multi-species assemblages. The code, created using “Microsoft Visual C++” and based on a species size and speed, calculates the amount of time needed to exit caves as a function of the size of the entrance. Based on these analyses, it is possible to assess the role of the dimensions of the cave opening in limiting the number of bats. The output of this model was improved by developing a second system dynamics model using STELLA. This latter model was fitted to real data to determine the spacing between bats as they exit the cave. The results offer an insight into the mechanisms underlying community structuring of Antillean bats. The final objective is achieved by simulating a grid that causes a reduction in the number of bats that can exit the cave per unit time, providing some insight into the potential impact of conservation strategies such as cave gating.

Wind Energy and Bats: Using Predictive Modeling to Enhance Conservation Efforts

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Wind energy has long been presented as an environmentally-friendly, renewable source that reduces dependence on fossil fuels and produces no emissions. However, recent studies showing increase bird and bat mortality caused by turbines have generated much interest. Of particular concern are specific sites that have experienced high mortality rates, such as the 44-turbine Mountaineer Center in WV. Here, 400+ bats died in a span of less than three months, during the fall migration period of 2003. The actual number of bats killed was likely much higher, given that sampling was on a weekly basis and scavengers may have removed animals from the site. Studies to date on bat mortality at wind power sites have been sporadic, and the techniques used as well as sampling efforts have not been standardized. Thus many questions remain about the factors that may cause bat mortality. Studies are planned to examine why some sites and some species are more likely to have mortality. Although such ecological studies may help us to understand proximal causes of mortality, their results will be difficult to extrapolate to other sites. Here, we present the initial stages of developing a GIS-based predictive model that examines the issue of why specific sites show higher mortality. This methodology utilizes multivariate analysis of environmental variables such as elevation, slope, and aspect along with temperature, precipitation, and wind to create a correlative potential distribution model of high mortality sites. When combined with species distribution data, this model may aid our understanding of why certain sites show higher mortality. It can also inform us as to locations where future turbine construction may be detrimental to bats.

Roosting Behavior and Dynamics of Habitat of Male Indiana Bats *Myotis sodalis* Following an Outbreak of Southern Pine Beetles *Dendroctonus frontalis* in Kentucky

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Most studies involving use of habitat by Indiana bats have been short-term investigations of maternity colonies during summer. Relatively little is known about behavior of male Indiana bats and few long-term studies have been attempted. We documented roosting behavior of a population of male Indiana bats that has been studied continuously since 1996. Bats were studied during 2001-2003, following an outbreak of southern pine beetles during 1999-2001. Increased availability of potential roosts following the outbreak was used to test hypotheses about roost fidelity. Roost trees were revisited to estimate how long trees may remain suitable for use by bats. Indiana bats (n = 25) roosted in a single core area (50% probability-use area) centered at the hibernaculum. Use of habitat by bats was correlated with high numbers of nearby dead trees. Most roosts (80%, n = 70 of 87) occurred in dead pines. Despite high numbers of dead pines made available by the outbreak, high numbers of nearby dead non-pines were the best predictor of habitat use. Logistic regression estimated 95% of roost trees fall within eight years of the date first located. Former core areas that were not used by bats during this study had low numbers of standing dead trees. Fidelity to roost trees did not decrease following increased availability of roosts. Thus, dynamics of availability and replacement of dead trees may have influenced location of core areas, but not fidelity to roost trees.

A Survey of Cave-dwelling Bats of the U.S.-Mexico Border

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The U.S.-Mexico border is home to the world's largest remaining bat populations, and these bats play vital economic and ecological roles. Some borderland bat species form enormous colonies in caves, and they are exceptionally vulnerable to human disturbance and vandalism. Such species will never be secure until key roosts are identified, protected, and monitored. Traditionally, bat conservation has emphasized protection of roosting caves on public lands, in many cases simply because those were the only roosts known to biologists. Additionally, we suspect there are at least half a dozen large, undocumented bat colonies on vast holdings of privately held land. Some such caves may contain, either currently or historically, huge bat colonies critical to long-term conservation success. It is imperative that we identify and assess these sites, and collaborate with land owners to determine and address bat needs before their populations are thoughtlessly destroyed. In 2003 we started a long-term project to identify, monitor, and protect the most important bat roosts in northern Mexico. To date we found eleven undocumented bat roosts in the Mexican states of Coahuila and Tamaulipas. Five of them are major free-tailed bat (*Tadarida brasiliensis*) caves and one was important for ghost-faced bats (*Mormoops megalophylla*) and cave myotis (*Myotis velifer*). Three free-tailed bat caves had been mined for guano, and the bat populations at two had been severely harmed by such activities within the last two years, and one had lost its entire population.

Roost Site Selection of Over-wintering Red Bats (*Lasiurus borealis*) in Southwest Missouri

Brad M. Mormann and Lynn W. Robbins, Southwest Missouri State University, Springfield, MO

Most roosting ecology studies of red bats *(Lasiurus borealis)* have focused on summer aspects of red bat roost selection with little attention given to the potentially more stressful winter migration and hibernation period. With more studies documenting red bats entering or leaving the leaf litter, our lab has formed objectives to determine if winter roosts (tree and leaf litter) are selected based on microhabitat differences within the landscape, and whether some red bats are year-round residents of southwest Missouri. We have attempted to answer these questions by: 1) identifying characteristics of winter roosts; 2) describing the location of winter roosts within the forest landscape; 3) comparing roost habitats with habitats of the surrounding forest; and 4) banding red bats in summer months and recapturing them during the winter. The results of this study suggest that red bats are selecting leaf litter and tree roosts in a non-random fashion. In particular, all leaf litter roosts were located on southern slopes among oak dominated leaf litter. Leaf litter depth, total stems, percent leaf litter ground cover, and temperature were found to be determining factors in the selection of winter leaf litter roosts. Trees were primary roosts when temperatures remained above freezing, with roost type switching occurring near or below 0^0C, a frequent occurrence in southwest Missouri. All tree roosts were found in oaks *(Quercus* sp.) with persistent leaves or eastern red cedars *(Juniperus virginianus).* Tree roosts were located between 1.75 and 6.5 m although available roosting sites at higher levels were readily available. Some red bats utilized only red cedars, some only oaks, and some a mixture of both for roost sites. Only males were captured and radio-tracked between November 1 and February 29, and no bats were recaptured from the summer banding period.

Leaf-modifying Behavior in *Artibeus lituratus* (Chiroptera: Phyllostomidae)

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We describe the manner in which males of the greater fruit bat, *Artibeus lituratus* (Phyllostomidae, Stenodermatinae) make small holes in leaves of the palm tree *Washingtonia* sp., apparently to improve the quality of diurnal roosts. This exclusive nocturnal behavior was observed and recorded on six occasions from November 2001 to January 2002 using an infrared video camera. Leaf-modifying behavior was observed only between 2000 and 2200 h, and was relatively brief (18 ± 14 s, n=5). Perforated leaves were not different from intact leaves except for the roughly circular or ellipsoidal array of holes (each about 2 mm in diameter) in the placations around the center of the leaf, near the rachis. None of the veins were modified. The pattern of perforations is best characterized as pleurocostal-ellipsoidal in shape in the medial region of the lamina. We propose the term "aggregate ellipsoidal" for the perforation pattern observed. This is the first report of *A. lituratus* modifying leaves, which we believe is similar to "tent-making" behavior described for other microchiropterans and megachiropterans. *A. lituratus* is the heaviest of the leaf-modifying bats, weighing 70 g. This is the first report that male stenodermines modify leaves at night and use them as diurnal roosts. We suggest that this species be included among other leaf-modifying or "tent-making" bats.

Mating System and Male Display Behavior of the Buffy Flower Bat, *Erophylla sezekorni*, in the Bahamas

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Most species of phyllostomid bats studied to date exhibit some form of harem polygynous mating system. However, very few species have been studied and the potential to uncover a more diverse array of mating strategies within the family certainly exists. Limited evidence indicates that the buffy flower bat, *Erophylla sezekorni*, a species endemic to the islands of the Greater Antilles, is another example of harem polygyny within the family Phyllostomidae. However, our observations of this species in the roost indicate that harem polygyny is most likely not the mating system of this species. Working on the islands of Exuma and Grand Bahama, we observed behavior of *Erophylla* within cave roosts using a Sony DCR-TRV25 Nightshot Camera equipped with an external IR source. Bats from several roosts were observed during three time periods from December 2002 (mating season) to June 2004 (maternity period). Our interest focused on the striking wing display behavior of male bats, similar to that observed in another phyllostomid bat, *Macrotus californicus*. We will describe this display behavior in detail and examine the roost structure of this species throughout the year. Though our results are preliminary, the mating system of *E. sezekorni* most closely resembles a lek, a mating system that is very rare in mammals.

The Role of Acoustic Cues for Species Recognition in Two Cryptic Species of Bats (*Hipposideros bicolor*): Playback Experiments

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Bats add an interesting twist to the study of communication. Many bat species use acoustic cues for both foraging and social communication, and therefore, natural selection on vocal and auditory apparatus for locating and capturing prey potentially constrains the evolution of vocalizations for social communication. Hipposiderid bats are of particular interest because they have auditory specializations that impose tight constraints on the design of echolocation signals, and as a result adults might be limited to a constant frequency for both echolocation and social communication. In Malaysia, *Hipposideros bicolor* has a bimodal distribution of echolocation call frequencies with some individuals echolocating at ca. 131 kHz and others ca. 142 kHz. Despite a large overlap in external morphology, these two phonic types are genetically distinct lineages. The observed difference in call frequencies between the phonic types is twice the predicted difference based on body size, and could reflect ecological and/or social selection on call frequency. Previous studies have suggested that individuals with intermediate call frequencies would be at a social disadvantage and selection would lead to a clear frequency band between phonic types. If this hypothesis is true, individuals should use echolocation calls or calls with the same frequency for social communication. The objective of this study is to test whether individuals of *H. bicolor* use playbacks of echolocation calls to recognize conspecifics. Individuals were placed at the base of a Y-maze and echolocation calls of 142-*H. bicolor*, 131-*H. bicolor*, or a control (background noise or no playback) were broadcast through an Ultra Sound Advice amplifier and loudspeaker situated at the end of one arm of the Y-maze. Trials ended when the bat traveled ≤ the distance down one arm or after five minutes. Preliminary results demonstrate a higher frequency of no response for the controls compared to echolocation calls, suggesting that bats heard and responded to calls being broadcast. There is no evidence, however, that individuals were able to distinguish between the two phonic types. This could be due to experimental error: bats may not have been able to distinguish which arm the sound was coming from, the echolocation calls may not have been recognizable to the bats due to distortions from recompressing and amplifying calls, or perhaps individuals were too stressed. It is also possible that individuals do not rely on echolocation calls for species recognition, but use other cues, such as olfaction, in addition to or instead of echolocation calls.

Preliminary Findings on Winter Roost Selection by Big Brown Bats (*Eptesicus fuscus*) Along a Plains-Mountain Interface

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Hibernation sites of bats may greatly influence their survival. Information gained on winter roost selection may thus be important in aiding management agencies in policy creation to protect species that may only be seasonal users of forests. It is largely unknown where many species of bats hibernate in the western parts of North America. We provide preliminary radio-tracking results that show big brown bats tagged at summer maternity colonies in the urban setting of Fort Collins, CO use rock crevices at higher elevations in the adjacent mountains as winter roosts. During the late summer and early fall of 2002 and 2003, radio-transmitters were put on 42 big brown bats of adequate weight. All left the summer roosting area. A total of 14 potential hibernacula as well as 23 transient roosts were identified, all in rock crevices. None of these bats used caves or mines as has been found in eastern parts of North America. These roosts were found as far as 133 km up the Cache La Poudre Canyon from Fort Collins, at elevations ranging from 345 to 1365 m above the city (actual elevations of 1871-2873 m.). Temperatures within the fissures during the winter period (November to April) averaged 2˚C (18 maximum to -16 minimum), and differed from an average temperature outside the roosts of 14˚C (34 maximum to -21 minimum). Seventeen out of 42-tagged individuals were eventually found at a mountain roost. Despite increased search effort (including tracking by aircraft), we were unable to locate the remaining 21 bats that left Fort Collins. We believe these bats also migrated to higher elevations but over a wider area of the surrounding mountains. The deep granite crevices that these bats choose may also be attenuating transmitter signals, allowing for some tagged bats to go undiscovered. These findings suggest a pattern whereby bats that inhabit urbanized areas along a plains-mountain interface during summer maternity periods make regional migrations to mountainous regions for hibernation, where they utilize deep rock crevices offering cool, constant temperatures.

Differential Use of Riparian, Open, and Forested Areas by Bats in the Nantahala National Forest, NC

Joy M. O'Keefe, Susan Loeb, and J. Drew Lanham, Clemson University, Clemson, SC

Foraging habitat is an important component of overall habitat for insectivorous bats, which spend as many as nine hours per night in search of food. Although riparian areas are generally considered important foraging habitat for bats, few studies have tested this assumption. Our objectives were to compare use of various riparian, forested, and open habitats to evaluate their importance as foraging and commuting habitat. From 7 -10 July, 2004, we simultaneously sampled bat echolocation calls in seven to eight habitat types in two watersheds on the Nantahala National Forest in western North Carolina. AnabatII bat detectors were placed at the center of small (~1 m wide) and medium (~3 m) streams, and near the center or on the edge facing into large (>9 m) streams; in the center of gated, grassy roads with an open canopy and open, gravel roads with a closed canopy; at the edge of a small pond; in wildlife openings; and in an interior forest. Detectors were operational from 20:30 to 6:30 EDT each night. The most commonly recorded species were big brown bats (*Eptesicus fuscus*), eastern red bats (*Lasiurus borealis*), northern bats (*Myotis septentrionalis*), and eastern pipistrelles (*Pipistrellus subflavus*). We subdivided the total pulses recorded (n = 101,017) by hour and habitat type for each night of sampling and used the mean number of pulses as an index of activity. Activity was highest from 22:00 – 22:59 (mean = 743.8) and declined through the night, with lowest activity from 5:00 5:59 (mean = 166.5). Activity was greatest over large streams (mean = 16,354), followed by wildlife openings, gated roads, and gravel roads combined (mean = 2,804), ponds and medium streams (mean = 267), and lowest in interior forest and over small streams (mean = 52). Thus, although large streams appear to be important foraging habitat for insectivorous bats on the Nantahala National Forest, gated and gravel roads also appear to be significant foraging habitats or flight corridors. These results may downplay the importance of non-linear wildlife openings, because, for insectivorous bats, they probably function solely as foraging habitat. Further, although ponds, medium streams, and small streams were used, they were not as important as other habitats, indicating that not all riparian areas function in a similar manner.

Serological Status of Bats in Relation to Rabies: What Does the Presence of Anti-rabies Virus Neutralizing Antibodies Mean?

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Our group has conducted field and laboratory studies on the presence of anti-rabies virus neutralizing antibodies (VNA) in bats. We conducted a serology survey of over 2,000 big brown bats (*Eptesicus fuscus*) at multiple colony sites in Fort Collins, Colorado in 2001, 2002, and 2003. Bats were marked with passive integrated transponder (PIT) tags for subsequent determination of their fate and repeat blood sampling of known individuals. Sera were analyzed for the presence of rabies VNA using the Rapid Fluorescent Focus Inhibition Test (RFFIT). Seropositive bats were found in every maternity colony, typically at 20-25 % of adult females. We also sampled big brown bats elsewhere in Colorado, and bats of six species in Colorado and New Mexico. All groups included seropositive individuals. Isolation of IgG from a sample of rabies seropositive big brown bats and its subsequent effect in RFFIT results demonstrated that the IgG fraction in the serum neutralizes rabies virus. Seropositive big brown bats were recaptured or demonstrated to be alive by PIT readers 1-3 years following initial detection of VNA. Antibodies also persisted 1-2 years after the first sampling, longer than any expected incubation period for rabies. We also report: reverse transcriptase polymerase chain reaction (RT-PCR) assays for detection of rabies virus genome in tissues of seropositive bats known alive one year after initial blood sampling (no evidence found); RT-PCR assays for rabies genome in saliva of seropositive bats (no evidence found); seroprevalence by age groupings of bats; and evidence for maternally transferred rabies VNA. Although there are a number of competing hypotheses to explain the presence of rabies VNA in serum, we believe our findings are most compatible with the hypothesis that bats are commonly exposed to the rabies virus and can acquire immunity. We suggest several non-mutually exclusive mechanisms for acquired immunity to rabies in bats based on experimental and observational data. These mechanisms may include low-dose exposure to virus (e.g., during grooming), low-dose exposure through bites, exposure to virus prior to loss of maternal antibodies, and perhaps exposure to less virulent strains of rabies. The immunity conferred to segments of bat populations and their ability to endure some level of RV exposure may explain why widespread decimation of entire colonies of bats by rabies epizootics is seldom observed. This may also be consistent with molecular data suggesting longer co-evolution between rabies and bats than between rabies and other mammals.

Frogs, Toads, or Bob Marley? Flexibility and Learning in the Frog-eating Bat, *Trachops cirrhosus*

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The fringe-lipped bat, *Trachops cirrhosus* (Phyllostomidae), feeds on frogs, using frog advertisement calls to detect, identify, and localize its prey. Given acoustic cues alone, *T. cirrhosus* is able to discriminate between poisonous and palatable prey species. The auditory system of *T. cirrhosus* is highly modified for low-frequency hearing and may be specially adapted for frog call detection; however, *T. cirrhosus* is opportunistic in its acquisition of prey, and feeds on a wide variety of prey items. *T. cirrhosus* may specialize on frogs during the wet season, but may be forced to feed on alternate prey items during the dry season when frog advertisement calls are infrequent. Given the foraging plasticity of this species, we hypothesized that the strong associations between acoustic stimulus and prey quality are largely learned and are flexible. We tested the ability of *T. cirrhosus* to reverse its response to the calls of its preferred prey species, the túngara frog (*Physalaemus pustulosus*) and its response to the calls of the unpalatable marine toad (*Bufo marinus*). We found rapid reversal learning, supporting the hypothesis that rather than being fixed, this bat's associations between prey cue and prey quality are highly flexible. We tested for the social transfer of a learned foraging preference, and found that novel foraging responses be rapidly transferred via social learning. These studies demonstrate a high degree of flexibility in this bat's foraging abilities, and point to the role of learning in foraging success.

A Novel, Non-invasive Technique for Assessing Bat Cranial Morphometrics

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Morphological measurements have been and continue to be the primary source to assess organisms' taxonomic, evolutionary, and ecological relationships within and among species. Traditional methods rely on euthanizing the animal, taking wing measurements, and extracting and cleaning the skull. However, thousands of fluid-preserved specimens are conserved largely unused in natural history museums because of the difficulty in taking cranial measurements from whole animals. With the advent of new technology, a better method may be on the horizon: Computed Tomography (CT) imaging, also known as "CAT scanning" (Computed Axial Tomography) is a technique for viewing the internal (both skeletal and soft tissue) structures of organisms. It provides a three dimensional perspective of the body that x-rays are unable to yield. Images obtained from the scan can then be manipulated three-dimensionally to focus on particular structures; most importantly, accurate measurements can be taken from the images. This technology has been used for human diagnostics for years and its use on biomedical research animals has been on an increase. However, to our knowledge no one has yet used CT scanning for ecological purposes. Here, we present CAT–scan data from a sample of bats. We first scanned the fluid–preserved bats and took measurements from the scanned images. Skulls then were extracted, cleaned, and re–measured. The two data sets were compared and the accuracy of the measurements statistically assessed. This method has enormous potential for bat conservation. Fewer specimens will need to be collected because existing specimens will find new usefulness. In the near future it may also be possible to scan live animals in the field using progressively smaller equipment, thereby reducing the number of bats collected for ecological studies.

Two-year Prevalence and Intensity Survey of Ectoparasites of the Big Brown Bat, *Eptesicus fuscus*, in Fort Collins, Colorado

Roger D. Pearce, Thomas J. O'Shea, Colorado State University, Fort Collins, CO; United States Geological Survey, Fort Collins, CO

A five-year study of population ecology and dynamics of rabies transmission in urban big brown bats (*Eptesicus fuscus*) was initiated in 2001 in Fort Collins, Colorado. During the summers of 2002 and 2003, prevalence and intensity of ectoparasite species commonly found on *E. fuscus* were observed and recorded. Ectoparasites of *E. fuscus* were systematically counted on over 1100 individuals (adult females, volant juvenile females, and volant juvenile males) in 2002, and over 1300 individuals in 2003. Prevalence and intensity data were collected from 14 roosts in both 2002 and 2003 with 231 marked individual bats sampled in both years. Using voucher ectoparasite specimens collected during each summer, the ectoparasites were correctly identified to species and confirmed by an expert. The most common ectoparasite observed during both summer seasons was the macronyssid mite, *Steatonyssus occidentalis*. Other acari of particular interest were *Spinturnix bakeri* and the chigger, *Leptotrombidium myoti*. Insect parasites observed were the batbug, *Cimex pilosellus*, the bat flea, *Myodopsylla borealis*, and the bat fly, *Basilia forcipata*. We made comparisons of prevalence and intensity of ectoparasites across roosts and years.

BAT and the Other Forgotten 'Birds of Prey' of the U.S. Navy in WWII

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Early in World War II, German U-boats were sinking alarming numbers of Allied shipping along the eastern seaboard of the United States. This was a national emergency and the military was willing to entertain any solution to U-boat scourge. A family of secret weapons was developed to evaluate several guidance systems including radio-control, television, radar, and even an organic guidance system (pigeons). In 1941, television and radar were new, untried inventions and engineers struggled through numerous developmental problems before an operating weapon system emerged during the last months of the war – the BAT (SWOD Mk 9). Like its namesake, BAT carried its own radar guidance system based on the cavity-magnetron, a device now found in microwave ovens. Engineers encountered many problems as they attempted to integrate the new technology of radar with the demands of target acquisition and pursuit in a missile system. However, Chiroptera solved these technical problems approximately 40 mya. Whereas Chiroptera employ an inherently unstable, albeit highly maneuverable airframe, BAT was based on a stable airframe that eliminated control problems for a task that did not demand maneuverability. BAT emitted 92-mm pulsed-radar signals through a parabolic reflector that alternately collected the return-signal for processing. It was more economical to use one antenna to both transmit/receive, which meant that it could not transmit/receive at the same time. Additionally, BAT had to send out a powerful pulse and receive a faint echo; without a circuit element to disconnect these two functions, the receiver would be overloaded and destroyed by its own signals. Chiroptera solved this issue via precise control over the tympanic reflex (self-deafening). Electronic circuitry in the 1940's was incapable of adjusting for Doppler shifts, and the creation of a receiver with sufficient dynamic range to accommodate for increasing signal strength of the returning echo as the missile approached the target was a major engineering stumbling block. Chiroptera employ a wide range of call structures, variations in call amplitude, Doppler-correction, and changes in head position to adjust for target location, size, and activity; BAT and its' vacuum tubes were limited to a fixed frequency, non-steer-able antennae, and were very easily defeated by enemy radar-jamming strategies.

An Assessment of a Snag Model for Bats Roosting in Douglas Fir Forests

J. Mark Perkins, Andrew J. Perkins, Brian J. Perkins, and Joshua Schmeiser, Portland, OR

Snags (dead or defective trees) in forest zones have been demonstrated as important bat day roosts, and in particular, maternity roosts by numerous peer-reviewed and gray literature papers. Characteristics that were common to most roosts discovered included a minimum dbh, minimum height, amount of solar exposure, stage of decay, visible by ocular inspection and within 1 km of perennial water. We sampled a total of 76 snags for bats (36 fit, 40 unfit). Results indicate significant differences in numbers of exiting bats detected between fit and unfit snags. The common characteristics for all snags from which bats flew were: visible roosts, stage of decay, and amount of solar exposure.

Intraspecific Genetic Variability within the Endangered Bat, *Corynorhinus townsendii virginianus*

Antoinette J. Piaggio, University of Colorado, Boulder, CO

The Virginia big-eared bat, a subspecies of *Corynorhinus townsendii*, was listed as an endangered species in 1979. There has been mark-recapture, natural history, and ecology studies of these bats, but to date there has not been any detailed population genetics studies of this group. Previous molecular phylogenetic work has confirmed monophyly and subspecific status of this taxon. The purpose of this study was to examine population demographics, degree of gene flow, and genetic diversity among populations of *C. t. virginianus* inferred from mitochondrial DNA and autosomal microsatellites. Samples were collected from three of the four states within the range of these bats. Samples from five roosts in West Virginia, one roost in Virginia, and three roosts in Kentucky were collected for a total of 72 individuals. Results from this work will be presented and this information will be used to make management and conservation recommendations.

Bat Use of Giant Sequoias in Yosemite National Park

Elizabeth D. Pierson, William E. Rainey, Leslie S. Chow, Chris J. Corben, Mary Ellen Colberg, and Winifred Frick, Berkeley, CA; UC Berkeley, Berkeley, CA; Yosemite National Park, CA, Columbia, MO; Mt. Shasta, CA; Oregon State University, Corvallis, OR

Research on forest-dwelling bats has focused primarily on the conservation and management of bat populations in habitats subject to timber harvest. Consequently, more information is available regarding bat populations in coast redwood (*Sequoia sempervirens*) than in giant sequoia (*Sequoiadendron giganteum*) forests. In a two year study in Yosemite National Park, we investigated bat use of Giant Sequoia groves using four approaches: collecting guano on suspended debris traps placed inside fire-scarred hollows (27 in the Mariposa Grove; nine in the Merced Grove); capturing bats using mist nets set at potential tree roosts, over streams, along trails, and in wet meadows; conducting acoustic surveys to sample bat activity in four habitat categories (hollow trees, streams, wet meadows, and rock outcrops); radio-tracking 16 individuals of five species to locate roost sites and assess foraging behavior. We discuss how the use of multiple approaches enhances our understanding of the bat assemblage in this unique forest type.

Ecological Interactions between the Mexican Free-tailed Bat and the European Corn Borer: A Model for the Effects of *Bt* Crops on Bats and Insect Resistance Dynamics

Tom Purucker and Tom Hallam, University of Tennessee, Knoxville, TN

Potential risks from the release of genetically modified organisms include indirect effects, such as the ecological effects of the diminishment of a pest population on other species in a community. This poster focuses on a mostly-neglected effect of the implementation of genetically-modified corn, indirect effects on the Mexican free-tailed bat, and the effects that foraging bats may have on the implementation of genetically-modified crops via their potential effects on the evolution of resistance. Indirect effects have already been demonstrated for herbicide-tolerant crops, which lead to lower food availability for seed specialists, and for control of the Colorado potato beetle, which resulted in a decrease in predatory specialists. An additional concern is the effects of bats on the evolution of resistance in European corn borers. It has been estimated that up to 100,000,000 Mexican free-tailed bats are present in Texas during the summer. Prey items are mostly beetles and moths such as the European corn borer. There are also millions of hectares planted with *Bt* corn in the U.S. now, so the potential selection for developing resistance in insect populations is strong. The current strategy for delaying resistance is a combination of a high *Bt* dose to the insect and the creation of a corn refuge in close proximity, so that susceptible insects will mate with insects that develop resistance. A simple model is developed to explore the ecological interactions of bats and European corn borers in the presence of genetically modified crops. Results are presented regarding the dynamics of time to resistance to *Bt* corn in the European corn borer, and the effects of *Bt* implementation on bat and European corn borer population dynamics.

Ecology and Conservation of Malagasy Bats
Paul Racey, University of Aberdeen, UK

Madagascar has nearly as many bat species as lemurs and, like lemurs, new species are still being described. The island's bat fauna is a distinctive mix of African and Asian genera and about half of the ca. thirty species are endemic. Despite this, little is known about Madagascar's bats. A group of studies were established to ascertain the extent to which two of the island's three endemic fruit bat species pollinate and disperse the seeds of forest plants, as a potential lever of getting them onto the conservation agenda. Pollen or fruit remains from 109 plant species of 70 genera were identified from the feces and eject collected from beneath 11 roosts of *Pteropus rufus* and *Eidolon dupreanum*. This apparently broad diet is not due simply to the wide range of habitats from which samples were collected, because 22 plant species were represented in feces collected over an eight-month period beneath a single *Eidolon* roost. For 80% of 20 plant species tested, seeds recovered from bat feces were more likely to germinate within 4-8 weeks than those of the same species taken from intact fruit. The largest bat species, *Pteropus rufus*, traveled nightly distances of up to 30 km between feeding site and roost and may thus bring about genetic exchange between isolated patches of forest. A substantial proportion of Madagascar's forest plants may be heavily dependent on fruit bats for pollination and seed dispersal.

Bat Surveys with Passive Acoustic Detection Systems
William E. Rainey, Chris J. Corben, Elizabeth D. Pierson, and Leslie S. Chow, UC Berkeley, Berkeley, CA; Columbia, MO; Berkeley, CA; Yosemite National Park, CA

Passive acoustic detection systems with low power requirements offer a time efficient and relatively inexpensive method of investigating bat activity and species assemblages over a range of geographic and temporal scales. With single or multiple systems operated for varied intervals, it is possible to examine: 1) night to night variation in bat activity at single sites in relation to local environmental variables (e.g., temperature, wind, insect emergence); 2) variation in activity at multiple sites within or among habitat types; and 3) seasonal patterns. In exploring this approach, we have sampled year-round bat activity at selected elevations in Yosemite National Park, detected presumptive migration events in the Central Valley (e.g., late summer activity pulses by red bats, *Lasiurus blossevillii*), and sampled habitats (e.g., cliff edges, open sagebrush) that present challenges to capture methods. The approach is convenient for assessing the distribution of infrequently captured special concern species that are readily identifiable acoustically (e.g., mastiff, *Eumops perotis*; spotted *Euderma maculatum*; and red bats).

Use of Torpor by Pallid Bats (*Antrozous pallidus*) at the Northern Extreme of the Species' North American Range
Daniela Rambaldini, University of Regina, Regina, SK

Torpor is a physiological adaptation that helps minimize energy expenditure and water loss during periods of inclement weather and/or low prey availability. Torpor can help desert-adapted animals survive harsh conditions - extreme fluctuations between day and night temperatures, low precipitation, and an unpredictable food supply. *Antrozous pallidus* (Vespertilionidae) is a desert-adapted species that reaches the northern limits of its range in the Okanagan Valley of British Columbia, Canada. The purpose of this study was to investigate torpor use by free-ranging male pallid bats in British Columbia. From June to August 2003, all bats (n = 8), with the exception of one, used torpor everyday (n = 54 days). Bats occasionally had two bouts of torpor per day (n = 19 days), but bats did not use torpor at night. Mean rate of arousal from torpor was significantly slower than the mean reported for pallid bats from Nevada. Bats spent an average of 18.7 hours in the day roost and spent 62.8 ± 2.8% of roosting time in torpor. When bats roosted for longer periods, torpor bouts were deeper. Ambient temperature (Ta) predicted the variance observed in the proportion of time a roosting bat spent in torpor, whereas length of time spent in the day roost did not. All day roosts I found were inaccessible rock crevices in mountains or cliffs. I calculated body condition index (BCI) as an indication of the nutritional state of each bat. On cool days, BCI and mass were more important predictors of torpor depth than was Ta, but on warm days Ta was a stronger predictor of depth and duration. Bats had longer and deeper bouts when foraging periods the previous night were shorter, and bats foraged for shorter periods following days when torpor bouts were longer. Male pallid bats in British Columbia maximized use of torpor, as I predicted for a desert-adapted species inhabiting the northern edge of its range.

Assessment of Fluctuations in Populational Composition of Summer Colonies of Endangered Gray Bats (*Myotis grisescens*): Preliminary Results

Petra Redinger and Troy L. Best, Auburn University, AL

In recent years, personnel of the Department of Conservation and Natural Resources, State Lands Division, have estimated the size of the population of gray bats (*Myotis grisescens*) at Blowing Springs Cave, Lauderdale Co., Alabama, at irregular intervals. Personnel associated with this monitoring effort noticed that when the cave was revisited through the annual activity season, there were noticeably differing numbers of bats exiting the cave. This has prompted me to question if there is significant variation in sex and age composition of the population in Blowing Springs Cave throughout summer. For data comparison, Anderson Cave in Shelby Co., Alabama, also was monitored to see if similar fluctuations occur there. Field work is being conducted to capture, examine, and immediately release gray bats between March and November of 2004 and 2005. Two nights were spent at each site during each visit. An estimate of the number of bats exiting the caves was done in the first night, and capturing, examining, and releasing the following night. Both colonies were maternity colonies. Significant fluctuations in numbers and changes in sex-age ratios were observed in both colonies. Numbers of bats increased after hibernation, decreased during gestation and lactation periods, and doubled in size with volant young. Numbers were still increasing toward the end of summer. Fluctuations are similar between the two caves, whereas sex-age ratios show differences. This may be due to different factors such as different cave anatomies and possible trap avoidance by adults by using a second exit (Blowing Springs Cave). Emergence at Blowing Springs Cave generally is later and shows waves of emergence intensity, sometimes with three to four peaks. Because this does not occur at Anderson Cave and probably does not occur to avoid the trap, I was prompted to question whether other factors contribute. Both caves are protected by law, but are accessible and being visited by cavers and the public. Whereas the caving community is largely informed and concerned with protection of these colonies, and avoids cave exploration between April and November, caves seem to be frequented by the public. Especially at Blowing Springs Cave, mostly beer cans, but also other trash, signs of fires, ATV and horse tracks, indicate activity. More intense measures have to be taken to protect gray bat colonies at Blowing Springs and Anderson Cave.

***Bats, Guano, and Ecosystems**

Jonathan Reichard, Louise Allen, Gary F. McCracken, and Thomas H. Kunz, Boston University, Boston, MA; University of Tennessee, Knoxville, TN

*** Jonathan Reichard** received the **Speleobooks Award**

Brazilian free-tailed bats, *Tadarida brasiliensis*, inhabit caves, bridges, and buildings throughout their distributional range in the southwestern United States. These bats provide a noteworthy ecosystem service by feeding on a variety of insects including important agricultural pests. Another less studied service is the recycling of nutrients such as nitrogen, phosphorous, calcium, magnesium, and potassium back into the ecosystem. Cave-dwelling bats deposit a large amount of guano beneath their roosts, but *T. brasiliensis* should also deposit a significant amount of nutrient-rich guano over adjacent landscapes during foraging bouts and the long return flights to their roosts. Rates of guano production were investigated at Ney Cave in Bandera, Texas to estimate how much guano could potentially have been deposited by individual bats in flight and in the cave roost. Historic and current census data were used to estimate the number of bats that dispersed and foraged nightly over the local landscape. We also attained dispersal distance and flight duration estimates from NEXRAD Doppler radar images. Guano was analyzed for nitrogen and phosphorous content. Using census data, nightly dispersal patterns, rates of guano production, and nutrient concentrations in guano, we estimated the nightly input of nitrogen and phosphorous to the ecosystem by *T. brasiliensis*. In much of the study area, where topsoil is thin and decomposition is slow, redistribution of nutrients by these bats provides an important fertilizing service to both natural and agricultural ecosystems.

Pre-construction Assessment of Habitat Use by Bats at the Flat Rock Wind Power Facility, New York

D. Scott Reynolds, St. Paul's School, North East Ecological Services, Concord, NH

Wind power has the potential for providing abundant clean energy and reducing our reliance on fossil fuels. Historically, this promise has been balanced by concerns about bird mortality and aesthetics. However, the 2003 mortality event at a wind farm in West Virginia has prompted developers to also assess the potential impact of wind farms on bats. During the summer of 2004, we did an extensive habitat survey of bats at the proposed Flat Rock Wind Power site on the Tug Hill Plateau of western New York. Twenty net sites were chosen across the study area in a variety of habitats. Thirty-five bats from three species (*Myotis lucifugus*, *M. septentrionalis*, and *Eptesicus fuscus*) were captured despite a total sampling effort of 130 net-nights. Capture sex ratio across the project was 0.74, but excluding a single site increased this ratio to 0.96. Captured bats were light-tagged and followed using night-vision binoculars to determine habitat use and flight altitude. These data suggest that most bats commute near the canopy height (approximately 10 m) along field edges and ground height (< 3 m) when traveling in narrow corridors. In addition to mist netting, Anabat acoustic monitoring was conducted across the study area. A total of thirty five complete nights of sampling data revealed much higher activity and species diversity than indicated by capture data. This included documentation of all three tree-roosting migratory species (*Lasiurus borealis*, *L. cinereus*, and *Lasionycteris noctivagans*), which appear most susceptible to turbine collisions. These data collectively suggest that species diversity and habitat usage is low during the summer, and therefore, population-level impacts are likely to be insignificant. We are currently collecting acoustic and radar data to assess the extent of migratory activity across the project area.

Food Availability and Animal Migrations: The Peculiar Behavior of the Straw-colored Fruit Bat at Kasanka National Park, Zambia

Heidi V. Richter and Graeme S. Cumming, University of Florida, Gainesville, FL

Animal populations usually migrate to increase food availability or reproductive success, or to decrease competition, parasitism, or predation. No research has focused on the drivers of migration in African Megachiroptera. This study examined the causes of the annual migration of an estimated eight to ten million *Eidolon helvum* through a Zambian national park. We tested the hypothesis that *E. helvum* migrates to opportunistically exploit seasonal variations in food supply. We used phenology data combined with feeding observations, mist netting, and monitoring of fruit bat movements to test the food availability hypothesis. The results provide the first quantitative evidence to support the hypothesis that the migration of *E. helvum* in Zambia is driven by food supply. The arrival of the colony coincided with an increase in the number of fruiting trees in the genera *Syzygium* and *Uapaca*; the colony departed when these fruit resources were largely depleted. *Eidolon helvum* may be utilizing the super-abundant food supply in Zambia to fulfill parental demands. Unlike many other populations, the females in this colony may migrate when pregnant and energetic demands are high. Furthermore, asynchrony in female reproductive cycles suggests that satellite colonies aggregate during this time of peak food production, although *E. helvum* usually responds to abundant food supplies by dispersing and forming smaller colonies. Mist netting over a two-month period resulted in a surprising lack of *E. helvum* captures; however, five other fruit bat species were captured. Explanations for this result include vertical stratification in the fruit bat assemblage and foraging by *E. helvum* in deforested agricultural areas surrounding the national park. Both the size of the *E. helvum* colony and its potential for long-distance movements imply important economic and ecological migration effects on a significant portion of sub-Saharan African. Migration paths are still unknown, and the arrival and departure of the migratory *E. helvum* colony in Zambia does not coincide with the dispersal or formation of other recorded colonies. The results of this study provide a scientific foundation for further research into multiple scales of movement by *E. helvum*, and demonstrate a need for the use of satellite collars to understand their small- and large-scale foraging ecology.

***What Makes Vampires Such Great Crawlers?**

Daniel K. Riskin, John E. A. Bertram, and John W. Hermanson, Cornell University, Ithaca, NY; University of Calgary, Calgary, AB

*** Dan Riskin** received the **Bat Conservation International Award**

The improved ability of the vampires over other bats to walk on the ground has previously been attributed to the fact that their hindlimbs are more robust than those of most bats. Here, we demonstrate that coordinated walking does not depend on increased weight support by the hind limbs. By measuring hindlimb ground reaction forces of agile vampires (*Desmodus rotundus*, n=8 and *Diaemus youngi*, n=2) and a similarly sized bat species with poor walking ability (*Pteronotus parnellii*, n=6) over 65 walking trials, we found that the net direction of peak hindlimb ground reaction forces was directed nearly vertically in *D. rotundus* and *D. youngi* (medians both 76.4˚ from horizontal), while forces produced by *P. parnellii* were significantly less vertical (median 61.7˚) ($p<0.05$). Contrary to the predictions of the robust hindlimb hypothesis, we found that at the time of peak hindlimb force production, the legs of *P. parnellii* were loaded with larger and highly variable forces (93.5% percent of body weight ± 36.6%)

compared to those of *D. rotundus* (69.3 ± 8.1%) or *D. youngi* (75.0 ± 6.2%) ($p<0.05$). Because the relatively larger forces of *P. parnellii* were oriented further from the vertical axis than those of the vampires, vertical hindlimb forces were not significantly different in the three taxa studied ($p=0.09$), indicating a common mechanical requirement for support of body weight against gravity. We discuss the kinematics of non-aerial locomotion in *D. rotundus* (n=6) in 64 sequences on a variable-speed treadmill, and compare their kinematics to those of terrestrial mammals to explain the non-aerial movement capabilities of the common vampire bat.

Reduce, Reuse, Recycle: The eBat Project
Lisa J. Roberts, Missy F. Young, Christopher M. Quick, and Sarah N. Gatson, Texas A&M University, College Station, TX

Bridging the gap between engineering and physiology is imperative for those interested in the integrative systems of the body. Animal models for this type of research have all but disappeared. Historically, bats were once prevalent research models, and the technical challenges of working with them were overcome. However, beginning in the 1960s their use almost dried up, and the knowledge base regarding their use in research has deteriorated. We have reintroduced bats as a research model, and have a chronic colony of pallid bats (*Antrozous pallidus*). Using our dedicated microscope, it is theoretically possible to do 400 non-terminal and non-anesthetized experiments a year on the same fourteen bats. To make best use of our unique lab resources requires the participation of many researchers, and we have developed an Internet-based interface that makes these resources available to those many potential researchers. Our microscope is connected to a computer that records everything observed during an experiment session. Each experiment session can, on the one hand, be recorded, archived, and made available to researchers not present during the experiment. On the other hand, because the microscope computer is also web-accessible, a remote researcher may participate in synchronous on-site experiments, as well as observe the lab activities through a web cam. We call this experience “eBat.” Participants may ask questions of the on-site researchers, get live responses, and participate in building an archived set of comments, questions, responses, and discussions available to all participants. We will encourage the building of a scientific community that will have the opportunity to collaborate in research, teaching, and learning. Thus, eBat seeks to facilitate the creation and use of primary scientific data by “out-sourcing” both labor and resources, yet re-centralizing these assets in an online site supported by the infrastructure of a global network. We seek to: build overlapping, diffuse, and multi-use community networks; fulfill the promise of distance learning; provide a structure for learning in the service of primary research; and build interest in basic science. There are many uses for bats in research, such as understanding how cancers grow, angiogenesis, angio-adaptation, and the functions of the lymphatic system. These research questions are best answered using the same live animals over and over. Therefore, minimizing animal use by reusing the eBat interface as both synchronous and asynchronous database and lab, we can reduce, reuse, and recycle.

The Effect of Moon Phase on Bat Activity in Two Mine Areas in Southwestern Utah
Keidy Guerrero Rusk, Nicholas J. Ervin, Kate Grandison, and John Taylor, Southern Utah University, Cedar City, UT

Bat activity in two southwestern Utah mine areas was monitored using internal infrared data loggers. Internal monitoring began in two mines in the Silver Reef mining district in February

2002, and in February 2003 inside the two Tushar Mountain mines. A linear model using events as the response and moon phase in percent as a predictor compared bat activity levels with moon phase. Changes in bat activity within the mines showed no correlation with moon phase. In addition, the 2004 bat activity at the mine entrances in both areas was monitored using infra-red digital video recorders during both the new moon and full moon. Bat exit and entrance behavior did not differ significantly with moon phase.

The Power of Hypothesis Testing in Phylogeography and Population Genetics: Lessons Learned from *Tadarida brasiliensis*

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Since the development of phylogeography, the field has been dominated by descriptive studies of genetic diversity within and between species, accompanied by post hoc explanations of the observed patterns. Although these types of studies can be informative for taxonomic and conservation purposes, they rarely offer a thorough examination of alternative scenarios, and often get mired in more subjective arguments (i.e., how much diversity is "enough," or what level of divergence is characteristic of subspecies/species/genera). Additionally, these descriptive studies often lack the statistical power that comes with rigorous hypothesis testing. I will review the types of hypotheses that are commonly tested in a phylogeographic framework, and will examine the impact of formulating and testing hypotheses in population genetic and phylogeographic studies. I will show the benefit of hypothesis testing and simulation analyses using a data set from *Tadarida brasiliensis*.

A Complex Inter-species Phylogeny Reveals Distinctive Biogeographic Patterns of Diversification in Triple Nose-leaf Bats (*Triaenops* spp.) in Madagascar

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The island of Madagascar has been isolated from other landmasses for the last 88 million years. This long period of isolation has resulted in a unique fauna, with high rates of endemicity among its native mammals, birds, fish, and reptiles. High levels of endemicity are found among Madagascar's bat fauna as well, with 60% of native bat species being endemic, including one family (Myzopodidae). We used mitochondrial DNA sequence data to examine phylogeographic structuring among species of the genus *Triaenops*. The species *T. furculus* and *T. rufus* are distributed sympatrically along the western coast of Madagascar, while *T. auritus* is known only from the type specimen collected from the extreme northern end of the island. A fourth species, *T. persicus*, is located in eastern Africa and Arabia. We found little differentiation among populations throughout the range of *T. rufus*. Similarly, populations of *T. furculus* from west-central and southwestern Madagascar show little differentiation. However, populations from the northern portion of the range of *T. furculus* are significantly differentiated from other parts of the species' range, and morphological evidence indicates that these populations may instead belong to *T. auritus*. These data are consistent with two potential hypotheses as to the origin of the genus: 1) an African origin with multiple crossings of the Mozambique Channel separating Africa from Madagascar, or 2) a Malagasy origin with subsequent dispersal into Africa.

Trees on Islands: Biogeographic Patterns of Diversification in Madagascar

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Biodiversity is the result of evolutionary processes that occur within a spatially and temporally explicit context. Rapid speciation may be more likely at a certain place and time if, for example, geological processes such as island formation create open niches that new species may exploit. Phylogenetic techniques can be useful for analyzing biodiversity by placing the evolution of a clade within a historical perspective. We show how phylogenetic techniques can inform biogeographic studies, and use the genus *Triaenops* as a case study for island phylogeography. The species *T. furculus* and *T. rufus* are distributed sympatrically along the western coast of Madagascar, while *T. auritus* is known only from the type specimen collected from the extreme northern end of the island. A fourth species, *T. persicus*, is located in eastern Africa and Arabia. We find little differentiation among populations from throughout the range of *T. rufus*. Similarly, populations of *T. furculus* from west-central and southwestern Madagascar show little differentiation. However, populations from the northern portion of the range of *T. furculus* are significantly differentiated from other parts of the species' range, and morphological evidence indicates that these populations may instead belong to *T. auritus*. These data are consistent with two potential hypotheses as to the origin of the genus: 1) an African origin with multiple crossings of the Mozambique Channel separating Africa from Madagascar, or 2) a Malagasy origin with subsequent dispersal into Africa.

Automated Detection and Tracking of Free-flying Bats using Digital Thermal Infrared Videography

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Thermal infrared imaging has been shown to be useful for detecting bats in flight and at rest. However, manual interpretation of thermal video imagery can be a tedious and time-consuming task, subject to interpreter error. We describe a new digital image processing technique for automated detection and tracking of bats in flight. The process is applicable to thermal video imagery collected with a stationary camera from a fixed field of view. Preliminary processing includes digital image capture and differencing of adjacent sequential frames. Image differencing acts to enhance detections by removing all stationary image clutter leaving only moving objects, thus no artificial background is required. Each moving object in a differenced frame exhibits two attributes: a positive value at the object's current location, and a negative value at the object's location in the previous frame. This makes it possible to determine the object's direction and speed in the image, and to predict its location in the next frame. No assumption of an organized flow of bats is required. Using this information, updated for every frame, the processing software acquires and tracks individual bats through a sequence of images. The primary output consists of an individual bat's location during each image frame in which it is tracked. These data can be further reduced to extract information including count of bats emerging from a particular subsection of the image, or determining type of flight (feeding vs. non-feeding) of an individual bat. We present data collected from three different scenarios: unidentified free-flying bats in open space (Ft. Knox, KY), small emergence of *Myotis austroriparius* from an abandoned cistern (Natchez, MS), and a large emergence of *M. grisescens* from Sauta Cave (Blowing Wind Cave, Scottsboro, AL).

Bat Habitat Models for the New River Gorge, Gauley River, and Bluestone River National Park Areas in the Central Appalachians of West Virginia

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Bat community surveys using acoustical methods are useful for generating generalized habitat associations in rugged areas, such as the central Appalachians, where traditional mist net survey efforts often are logistically difficult and may not provide complete data. We sampled the bat community on the New River Gorge, Gauley River, and Bluestone River National Park Areas in the central Appalachians of West Virginia using Anabat II system June-September 2003. Additionally, we recorded habitat measures, such as habitat type, stand class, mid-story percent, height and width of the forest canopy gap, height and width of the corridor, aspect, slope, and elevation, at each sample point in an attempt to produce species-specific habitat models for bats at the three areas. We detected ten bat species on the three parks, including several species of conservation concern, such as the small-footed myotis (*Myotis leibii*) and the endangered Indiana bat (*Myotis sodalis*). Although present, both were apparently uncommon with only 21 and 1 total calls recorded at 4 and 1 sample points for each, respectively. Calls of at least five species were recorded in all structural categories, but species composition varied among categories. *Lasiurus borealis*, *Eptesicus fuscus*, *M. lucifugus*, and *M. septentrionalis* were commonly recorded in all categories. Among stand age classes, bat activity generally was higher in the younger stand classes. However, activity of *M. lucifugus* was higher in the oldest stand class than in all other classes. *Lasiurus borealis*, *E. fuscus*, *M. lucifugus*, *M. septentrionalis*, and *Pipistrellus subflavus* were detected in all classes. The only species recorded above the canopy was *L. cinereus*. Resulting habitat models based on bat presence or absence will be discussed. Information gained from this study will aid in bat conservation efforts by providing land managers with valuable data regarding habitat use and will allow researchers to formulate testable hypotheses about bat habitat relationships to be definitively tested using radio-telemetry techniques.

***Corynorhinus rafinesquii* and *Myotis austroriparius* Use of Artificial Roosts in Southwestern Mississippi**

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Roost sites of Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) and southeastern myotis (*Myotis austroriparius*) were examined in abandoned buildings and cisterns at St. Catherine Creek National Wildlife Refuge, Hollywood Plantation, and Laurel Hill Plantation, Adams County, Mississippi, from March through December, 2002 and 2003 and April through August, 2004. Seven abandoned structures and one culvert were documented to serve as roost sites for *C. rafinesquii* on the refuge and plantation. Three of these sites were verified to be maternal roosts. One of the colonies contained 50 individuals in July 2003. Another maternal colony on property adjoining the refuge contained 35 *C. rafinesquii* in September 2002. Other structures supported from zero to nine individuals during the survey period. Six of the abandoned structures were also used by *M. austroriparius*, one of which contained five individuals. Two additional roosts for *M. austroriparius* were discovered in a cistern on Laurel Hill Plantation in

November 2002 and a cistern on Hollywood Plantation in April 2004. Using infrared imagery, 2194 individuals were counted emerging from the cistern on Laurel Hill Plantation on December 4, 2003. On May 22, 2004, 5893 individuals were counted emerging from the cistern on the Hollywood Plantation. Sixty-eight *C. rafinesquii* and 235 *M. austroriparius* were hand netted in the roosts after pups were volant. Captured bats were weighed, sexed, and measured. *C. rafinesquii* were banded using split ring bands. Standard mist netting was conducted at 24 sites on the refuge and plantation from April through October, 2002 and 2003. Twenty-one *C. rafinesquii* were captured at three sites, representing 29% of all captures, and sixteen *M. austroriparius* were captured at five sites, representing 22 % of captures. Other bat species netted during the survey period included evening bats (*Nycticeius humeralis*, 31%), eastern red bats (*Lasiurus borealis*, 15%), and big brown bats (*Eptesicus fuscus*, 2%).

Bat Commuting: Night Roosting and Foraging Behavior in an Urban Landscape of a Townsend's Big-eared Bat (*Corynorhinus townsendii*)

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In the southwest, Townsend's big-eared bats are usually associated with caves and mines for roosting habitat, and are thought to be sensitive to human disturbance. Night-roosting has been documented in several species of bats, and has been described as ranging from short, solitary rests at random locations to relatively long respites in clusters that display fidelity to specific locations across multiple years. Nocturnal resting habits are still poorly described for most species. Night-roosting Townsend's big-eared bats have been observed using urban sites for night roosting in spring and fall for a number of years. In 2004, we attempted to document night-roosting and foraging behavior in an urban setting of a male Townsend's big-eared bat using acoustic monitoring and radio-telemetry techniques. Multiple day-roost locations were found in nearby canyon country during a two-week period. During radio-tracking efforts, the male was observed commuting from his canyon day-roost to town and foraging over homes. Night-roosting and social calls were documented using an ANABAT acoustic station. Commuting, foraging, and night-roosting behavior will be described.

Recording Ultrasonic Calls Simultaneously with Anabat and Pettersson Detectors

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Ultrasonic detectors are in wide use by biologists despite controversy regarding their best use. In part this is because of differences in capture/analysis capabilities of time-espansion and zero-crossing period meter detection systems. Obviously, we all want a system that is relatively inexpensive, relatively easy to use and analyze, and that will enable us to make correct interpretation of results. Such a system has the potential to allow land managers to identify the presence of species with minimal effort, and more importantly, to gather information that is not disturbing to bats. Unfortunately, many eager personnel who have acquired a detector system have quickly learned that sonar detectors and their associated computer packages are more complicated than they had anticipated. Also the possibility that the end results obtained from the detector system are equivocal is even worse. Recording, analyzing, and data managing the ultrasonic calls of bats is extremely time-consuming and tedious work. In order for the results to be used efficiently and effectively, there must be some method for increasing confidence in the ability to correctly identify species with the system that is used. We have been developing a sonar call library using both AnabatII and Pettersson D240x ultrasonic detectors simultaneously to record ultrasonic calls of bats. We captured calls on multiple AnabatII and multiple Pettersson detectors, and used Anabat6/Analook and Bat Sound Pro software, respectively, to download and interpret calls. The simultaneous use of two different detector systems provides additional call parameters for interpretation than is possible with each system alone. We present a comparison of ultrasonic calls by *Myotis velifer* in southern Arizona from Kartchner Caverns State Park and Fort Huachuca. Both localities have cave roosts of this species, and non-roost sites where we netted the species. We have obtained recordings of species-specific calls from identified bats during hand release, from identified bats exiting roosts, and from unidentified free flying bats.

A Total-evidence Phylogeny of Megabats: Implications for Understanding Biogeography and Dietary Evolution

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The suborder Megachiroptera comprises >160 species of fruit bats (Pteropodidae). Recent molecular phylogenies of megabats have indicated that most traditionally recognized taxonomic groups are not monophyletic, implying high levels of morphological homoplasy, particularly in traits related to feeding habits. Molecular studies have likewise suggested novel biogeographic hypotheses that seemingly contradict traditional ideas based on putative taxonomic relationships. However, a recent study has shown that the alleged conflict between morphology and molecular data may be less significant than previously thought. To further investigate this, we generated a morphological matrix of over 200 characters for 70 representative megachiropteran species and 6 microchiropteran outgroups. This sample includes members of all currently recognized megabat genera, and several species from the more speciose genera (*Pteropus*, *Dobsonia*, *Nyctimene*, *Rousettus*). We combined this matrix with sequences from the 12S, 16S, *t*-valine, cyt *b* and the nuclear c-mos oncogene from previous studies. We analyzed these data in a parsimony analysis using direct optimization under equal weights as implemented in POY. The combination of the two sources of evidence easily accommodated the morphological and molecular signals, yielding a well-resolved, well-supported phylogeny of the Megachiroptera that agrees remarkably well with the current taxonomy of the group. Using our new total-evidence phylogeny as a framework, we reexamined patterns of evolution of dietary traits (e.g., nectar feeding) and biogeographic hypotheses (e.g., origins of African megabats). We conclude that the history of Megachiroptera is complex, but morphological homoplasy and multiple geographic dispersal events (biogeographic homoplasy) are less common than often suggested.

Abundance of Insectivorous Bats at for Urban and Suburban Localities in Puerto Rico

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We examined four localities within the urban/suburban areas of the San Juan Metropolitan Region, Puerto Rico, the West Indies. At each one of these sites we established a monitoring station using Anabat, and the area was surveyed from sunset through midnight during the months of June and July 2003. Each site was sampled a total of eight nights. We measured vegetation cover on 1 km and 5 km concentric circles around the monitoring locality. We identified five or six of the thirteen species of bats present on the island in five families. *Molossus molossus* accounted for most of the records. We found no clear relationship between the abundance of insectivorous bats and vegetation cover. The heterogeneity of the sampling localities may be more important in determining diversity.

Diet, Sunlight, and Vitamin D in Bats (Chiroptera)

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It has been postulated that some source of vitamin D is required by all vertebrates to maintain adequate circulating calcium and skeletal health. Vitamin D may be synthesized in the skin upon exposure to ultraviolet-B radiation or ingested in the diet. Chiroptera, the second most speciose group of mammals, are primarily nocturnal and have a highly varied diet, thus considerable variation in vitamin D status can be expected. Little is known about the role of vitamin D in these organisms. Chosen for this study were five New World, cave-roosting species (*Artibeus jamaicensis*, *Brachyphylla cavernarum*, *Monophyllus redmani*, *Noctilio leporinus*, and *Desmodus rotundus*) represented by contrasting feeding habits (two frugivores, one nectarivore, one piscivore, and one sanguivore), and two Old World frugivores, one of which typically roosts in foliage (*Pteropus hypomelanus*) and another that roosts in caves (*Rousettus aegyptiacus*). A competitive protein-binding assay (CBPA) was used to evaluate 25-hydroxyvitamin D [25(OH)D], the major circulating metabolite, and high-performance liquid chromatography (HPLC) was used to evaluate circulating vitamin D_2/D_3. Results indicate that circulating 25(OH)D is extremely high in free-ranging species that consumed animal tissue (fish or blood) but extremely low in free-ranging species that consumed fruit and/or nectar. Results also indicate that both *P. hypomelanus* and *R. aegyptiacus* were capable of synthesizing vitamin D_3 in their skin when exposed to daily sunlight. The efficiency of synthesis varied however, possibly reflecting the relative amount of skin pigmentation. Results also indicate that these two species poorly absorb a single highly concentrated oral vitamin D_2/D_3 supplement, but repeated administration of a similarly concentrated supplement was successful in increasing 25(OH)D in *R. aegyptiacus*. Finally, the results suggest that *P. hypomelanus* discriminates against vitamin D_3 in favor of vitamin D_2. However, because of the small sample size, the latter results are inconclusive. Bats are a diverse group, and this is reflected in their vitamin D status. In species naturally exposed to sunlight, endogenous vitamin D_3 synthesis may be important to calcium homeostasis and bone health. However, in herbivorous, nocturnal species calcium homeostasis may require only minimal amounts of vitamin D or may function entirely independent of this substrate.

The Use of Sensory Cues for Foraging by Two Sympatric Neotropical Gleaning Bats

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The majority of insectivorous leaf-nosed bats (Phyllostomidae) are gleaners. Their prey is close to or on surfaces and consequently difficult to detect for an echolocation bat, as echoes from prey and background overlap. Gleaners thus often use other sensorial cues for foraging. We investigated the role of different sensorial cues for prey detection and localization in two representatives of the species-rich functional group of gleaning Phyllostomidae, *Micronycteris hirsuta* and *Tonatia saurophila*. In behavioral experiments in a flight cage we offered the bats katydids that produced sound, such as wingbeat, landing sounds on dry leaves, and communication calls. We also offered silent (stationary) katydids on different surfaces, and recorded all capture attempts. If mainly echolocation is used for prey detection and localization, silent and sound-producing insects should be taken equally. We performed all experiments under red light as well as in complete darkness, to test for the role of vision. In addition, we presented plastic dummies to the bats, to determine the role of shape, texture, and olfaction. Both species almost exclusively reacted to flight noises of katydids. Landing sound elicited a reaction from the bats to a lesser extent. Only *M. hirsuta* took silent stationary prey. Performance of bats was not affected by the presence or absence of light. Several *M. hirsuta* and only one individual of *T. saurophila*, attempted to "capture" a prey dummy. Both species proved to be mainly perch-hunters, but *M. hirsuta* also actively searched for prey, by slowly flying along the walls and floor of the flight cage. We suggest that both species use mainly prey-produced sounds for the detection and localization of prey, and echolocation for orientation in space. This is supported by an earlier study of the echolocating behavior of these species.

Evolution of the New World *Myotis* Inferred from Mitochondrial and Nuclear DNA

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Recent studies have shown that species in the genus *Myotis* have developed a number of convergent morphological features, many of which are more related to their mode of food procurement than their phylogeny. In particular such specializations as fish-eating are found in several, unrelated species (e.g. *Myotis vivesi* and *M. ricketti*). Surprisingly the biogeographic origins of species are a much better predictor of phylogenetic relationships, than their morphology. Within the worldwide radiation of *Myotis* analyzed to date, a strong, monophyletic clade includes all Nearctic and Neotropical species. Until now, only a third of the 38 New World species were included in this clade. In order to better understand the evolution of this clade, we present phylogenetic reconstructions of 15 Nearctic and 12 Neotropical species of *Myotis* compared to a number of Old World congeners. These reconstructions are based on both complete cytochrome *b* genes (mtDNA), and on RAG2 (ncDNA) sequences. The monophyly of the New World clade is strongly supported in all analyses. Two Palaearctic sister species, one from the west (*M. brandti*) and one from the east (*M. gracilis*) are imbedded within the New World clade, suggesting that they returned across the Bering Strait. An emerging feature of these phylogenetic reconstructions is that limited faunal exchanges took place between the North and South American continents, further stressing the importance of biogeography in the radiation of *Myotis*. Moreover, we use a fossil-calibrated, relaxed molecular clock to estimate divergence time of lineage divergence. We correlate these dates with major biogeographic events, and propose a timescale for the New World *Myotis* radiation.

Summer Use of Abandoned Mines by the Indiana Bat in Southern Illinois

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Greater than 35,000 Indiana bats (*Myotis sodalis*) hibernate in abandoned mines and caves in southern Illinois. Recently, we discovered that two of these large mines also house summer bachelor colonies. The two colonies contain greater than 5,000 male and non-reproductively active female Indiana bats. Smaller numbers of northern long-eared bats (*Myotis septentrionalis*) and southeastern bats (*Myotis austroriparius*) also occur. In 2003, all abandoned mines of the Unimin Specialty Mines Corporation, Alexander County, Illinois, were surveyed during the hibernation period. Of the 23 mines surveyed, five contained evidence of summer use in the form of large guano piles. We found an additional 1,000 Indiana bats in another mine during summer 2004. The total of 6,000 Indiana bats is approximately 17% of those hibernating in the area during the winter. Future surveys will determine if the mines that contained guano — but no bats — are truly abandoned, or if males switch roosts throughout the summer. Many male Indiana bats that hibernate in southern Illinois are using mines as roosts throughout the year instead of dispersing into the forest during the summer. This is not the typical summer roosting behavior of Indiana bats. Researchers in other areas should determine if bachelor colonies are established in caves or mines where only hibernating bats were thought to occur. If bachelor colonies are present, protective measures may be needed to prevent disturbance or destruction of these summer roost sites.

Historical Processes Enhance Patterns of Diversity along Latitudinal Gradients
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Much of the current debate surrounding the mechanistic basis to patterns of diversity can be attributed to the relative degree to which either historical or contemporary mechanisms determine empirical gradients. Nonetheless, few models describing how historical processes can contribute to contemporary patterns of diversity have been presented. Two such models (i.e., center of origin and time-for-speciation) describe diversification as a process of nonrandom diffusion and subsequent cladogenisis of species away from the particular place of origin of a higher taxon. Predictions of such models are: 1) species richness declines toward the periphery of the range of a higher taxon, 2) the amount of sequence divergence between a taxon and the putative ancestor of the entire clade is greatest toward the periphery than the center, 3) age of taxa is lower toward the periphery than the center, and 4) variance of sequence divergences and ages is highest toward the center and lower toward the periphery of the range of the higher taxon. I tested these predictions in an attempt to better understand the role of historical processes in the formation of one of the most ubiquitous patterns of biodiversity – the latitudinal gradient in species richness. Results indicate that four of five predictions are well supported for New World leaf-nosed bats and that diversification has had strong influences on latitudinal gradients of species richness. Contemporary and historical processes likely interact to produce cotemporary patterns of biodiversity. Nonetheless, the interdependence of contemporary and historical environments prevents the independent implication of either type of process in determining present-day patterns of diversity. Indeed, a better understanding of how the evolutionary diversification of taxa contributes to the formation of patterns of species richness along environmental gradients is necessary to fully understand spatial variation in biodiversity.

Local Scale Population Structure of the Common Vampire Bat (*Desmodus rotundus*)
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We examined mitochondrial genetic variation of common vampire bats (*Desmodus rotundus*) in western Tamaulipas, Mexico. The Sierra Madre Oriental Mountains, of Tamaulipas, are dissected by steep ridges and narrow valleys. Each valley is cut by an active creek, with farms and potential bat roosts distributed therein. Populations of *D. rotundus* were sampled to characterize demographically significant units, as determined by the scale of genetic structure. We sequenced the hyper-variable mitochondrial control region from approximately 100 individuals, collected from ten locales within Tamaulipas. *Desmodus rotundus* commonly forms polygynous mating groups of one adult male and a small number of females. Females typically remain in natal roosts, while juvenile males disperse to other colonies. Long distance dispersal in

D. rotundus is uncommon. We hypothesize that there will not be significant structure among populations within valleys, but significant matrilineal structure across populations of different valleys.

Evaluating Environmental Education Programs for Critically Endangered Fruit Bats in the Western Indian Ocean

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Environmental education programs have the potential to increase ecological awareness, foster favorable attitudes toward the environment, and promote natural resource conservation. As part of broader multidisciplinary conservation programs, environmental education programs have been established for three Critically Endangered fruit bats from economically poor Western Indian Ocean islands: Livingstone's flying fox, *Pteropus livingstonei*; the Pemba flying fox, *Pteropus voeltzkowi*; and Rodrigues flying fox, *Pteropus rodricensis*. We document the strategies used by these environmental education programs, and evaluate these programs' educational outcomes and conservation impacts. Educational interventions emphasized the development of educational materials (including posters, stickers, videos, and lesson plans) that linked human needs to the ecosystem services provided by bats. These materials were delivered to schools and community groups, and local environmental educators were trained to reinforce this message through informal discussion and through formal community meetings and workshops. Outcomes included increased local awareness about the bats and their conservation, increased training of environmental educators, inclusion of bat conservation and environmental issues in the school curricula, and the establishment of community-based environmental nongovernmental organizations. Factors contributing to the success of these interventions included extensive prior planning, presentations in local languages in multilingual situations, distribution of educational materials through existing networks of educators, participation in trainings by local educators, involvement by local environmental non-governmental organizations, and local capacity-building. The environmental education programs also made important contributions to other components of their respective conservation programs, especially in population monitoring programs. Nevertheless, long-term conservation impacts, particularly reducing habitat loss, have been slow to materialize, and social and economic issues remain to be addressed. Despite these difficulties, these environmental education programs have each established a strong foundation for future conservation actions.

Short-term Roost Fidelity of *Corynorhinus rafinesquii,* Rafinesque's Big-eared Bat

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Roost fidelity is a potentially important phenomenon in bats but is poorly understood, particularly with regard to how this behavior relates to availability of potential roosts and social relationships. From 2001-2003 we used radio-telemetry to assess roost fidelity of *Corynorhinus rafinesquii,* Rafinesque's big-eared bat, in DeSoto National Forest, Mississippi. Bats typically

used multiple roosts (mean = 2.5) and switched roosts 2.8 times during the ca. two-week period that they were monitored. One female used six different roosts over an eleven-day period. Based on maximum consecutive days spent at a roost, bats showed slightly higher fidelity to manmade structures than to trees (5.1 to 3.0). Five of 22 individuals returned to their capture sites (bridges or houses) while they were monitored, and we found 9 additional bats (of the 22) at their original roosts after their tracking periods had ended. One pair of bats (an adult female and a volant juvenile) roosted together inside an empty oil tank every day while monitored. The high fidelity of these individuals (and their colony) to this structure might have been due to the apparent paucity of natural roosts in the area (FR 206 North). In contrast, a group of three bats, which inhabited a different patch of forest (FR 202 West), each roosted in ≥ 3 hollow trees, switched roosts 6 times, and spent ≤ 4 consecutive days at any roost during ca. two weeks. Bats captured in the FR 202 West area used slightly more roosts than individuals captured in the area of FR 206 North (3.6 to 2.0) and showed lower roost fidelity. Our data suggest that roost fidelity in *C. rafinesquii* reflects a combination of environmental and social factors and is consistent with behavior of other forest-dwelling, crevice-roosting species of bats.

Effects of Modified Livestock Water Troughs on Bat Use

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Bats drink by skimming across a water surface. Livestock water troughs may potentially be an important water source for bats, especially during dry seasons or in areas lacking alternate water sources. However, dead bats have been found in livestock troughs, suggesting that although trough waters may attract bats, trough modifications may negatively affect bats' ability to access water safely and effectively. To determine whether trough modifications, such as wires and braces, affected bats, we conducted a series of experiments using video-monitored, paired troughs at the Raymond Wildlife Area in northern Arizona during June and July of 2004. When both rectangular troughs (4.6 x 1.7 m) and circular troughs (2.4 m dia) were modified by stretching three strands of barbed wire across the center, 54% (n = 453) and 57 % (n = 87) of approaches by bats were at or near the surface, while 82% (n =208) and 75% (n = 87) of approaches were at or near the surface on unmodified control toughs. When the water surface area of modified, rectangular troughs was reduced, the percentage of approaches at or near the surface decreased (41%; n = 643) compared to unmodified controls (79%; n = 375), indicating that trough surface area interacted with trough modification. Bats consistently changed straight-line approaches to 180 and 90 degree turns to avoid modifications. Along with the increased number of approaches needed to successfully drink from the surface, these flight behavior changes caused by modifications may be energetically expensive for bats, especially during periods of high-energy demands, such as parturition and lactation. No bats were injured, killed, or knocked into the water during our experiments. Nine bats made contact with modification wires, all at the modified troughs with smaller surface area, indicating that smaller troughs with wires may be posing higher risks of injury for bats.

Genetic Analyses Reveal Differing Evolutionary Histories in Two Sympatric Species of *Pteropus* in the South Pacific

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Geographic differentiation among populations of two species of *Pteropus* occurring in islands in the south-central Pacific was examined through mitochondrial DNA (mtDNA) sequence analysis. Data demonstrate significant genetic structuring in *Pteropus samoensis* among islands consistent with geologic (historic) isolation of islands, hence, isolation of gene pools. In contrast, *P. tonganus* populations shared substantial numbers of haplotypes among islands, although differentiation between the Samoan and Fijian island groups likewise reflects the influence of geographic isolation on the genetic structuring of the species. Both species exhibited similarly low levels of nucleotide diversity contrary to expectations based on contrasting population abundances, i.e., *P. samoensis* populations are characteristically of low abundance whereas *P. tonganus* populations are typically large. The differential impact of geographic isolation on genetic differentiation of these two sympatric species may be rooted in differences in sociality and behavior. Paradoxically, these behavioral differences may also have contributed to the similarly low levels of nucleotide diversity.

Individual Ultrasonic Voice Identification of the *Eptesicus fuscus* Population of Fort Collins, Colorado

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Echolocation calls are normally used by microchiropterans to locate and identify obstacles in their flight path, including prey. Variability in echolocation calls and responses of bats to playback presentations of them demonstrate that these signals also serve in communication. Previous laboratory-based studies of the big brown bat, *Eptesicus fuscus*, have indicated that their echolocation calls are variable and contain individual-specific information. My study was designed to investigate variability in the echolocation calls of *E. fuscus* recorded in the field, specifically as known individuals emerged from their roosts. I recorded calls using the Avisoft Ultrasoundgate 416 system, and analyzed calls from approximately 200 individuals, recording the following features for each call: call duration, frequency with most energy, lowest frequency, highest frequency, and interpulse interval. I used mulvariate statistics to assess call variation and the presence of individual signatures. This study provides an opportunity to determine whether individual voice signatures of *E. fuscus* recorded in a field situation provide the same results seen in previous laboratory studies.

Phylogenetic Relationships of the Genus *Platyrrhinus* (Chiroptera: Phyllostomidae)

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The genus *Platyrrhinus* is one of the most speciose genera in the Neotropical bat family Phyllostomidae. Phylogenetic relationships within *Platyrrhinus* have been previously examined using morphological data. In this study, phylogenetic relationships within *Platyrrhinus* are uncovered using five DNA sequences (about 4410 base pairs): the mitochondrial cytochrome *b*, ND2 and D-loop genes, and the nuclear Rag 1 and Rag 2 genes. Individuals from nine of the ten recognized species of *Platyrrhinus* were included in this study. Maximum likelihood and

Bayesian analyses produced similar topologies and uncovered three major clades: one comprising the smaller species, *P. brachycephalus* and *P. helleri*, plus *P. recifinus*; the second clade containing *P. aurarius*, *P. dorsalis* 1, *P. dorsalis* 2, *P. infuscus*, *P. nigellus*, *P. vittatus* 1, and *P. vittatus* 2; and the third clade containing *P. lineatus*. The monophyly of *Platyrrhinus* was supported, as was the subdivision of *Platyrrhinus dorsalis* and *P. vittatus* into three and two different taxa, respectively, as suggested in earlier morphological studies.

Phylogeography and Species Status of *Myotis volans*

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Recent genetic studies on bats have revealed a surprising degree of cryptic speciation – morphologically similar taxa representing distinct evolutionary lineages. Here I present a population genetic and phylogenetic analysis of evolutionary relationships within *Myotis volans*, and demonstrate that this species represents at least two highly divergent evolutionary lineages. I sequenced a portion of the mitochondrial control region and COI gene for ~125 individuals representing 19 populations and three of the four named subspecies (*M. v. longicrus*, *M. v. interior*, and *M. v. amotus*). Population genetic analyses (AMOVA) on six populations with large sample sizes revealed that this species was divided into southern and northern groups of populations that accounted for over 70% of the variation in haplotype frequencies. Phylogenetic analyses confirmed the presence of these lineages, which correspond to the northern subspecies (*M. v. longicrus*) and the combination of two sampled southern subspecies (*M. v. interior* and *M. v. amotus*). These lineages are highly divergent (9.1% mean sequence divergence for COI), are well supported in all phylogenetic analyses, and can easily be distinguished by unique 6 bp repeats in the hypervariable II portion of the control region. The northern lineage likely overlaps morphologically with *M. lucifugus*, as in a large sample of bats sequenced at COI, the greatest number of misidentifications occurred between these two taxa. My results confirm an earlier report of high sequence divergence between two *M. volans* specimens, and support earlier findings that there may be greater diversity among bats than was previously believed.

Lubee Bat Conservancy: Research and Worldwide Conservation Programs for Fruit and Nectar Bats

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Lubee Bat Conservancy is an international non-profit organization working with others to save fruit and nectar bats and their habitats through conservation, research, and education. Healthy ecosystems depend on fruit and nectar bats that pollinate flowers and disperse seeds. Lubee is working to promote understanding and responsible management of the vital relationship between bats, plants, and people, leading to a sustainable future for all. Our research and conservation programs are strategic and based on solid science. We maintain a living animal collection, linking field studies with conservation breeding, science, and training. We support worldwide field programs, increasing knowledge of species ecology and building capacity of communities to conserve bats and their essential ecosystem services through education and awareness. Everything we do is through partnerships – working with a global network of conservation scientists, conservation groups, educators, zoological and academic institutions, governments and local people. We present an overview of the current diverse research and conservation programs being supported by Lubee worldwide. These include projects examining the aeromechanics of highly maneuverable bats, physiology and behavior in the social Malayan flying fox and solitary golden-mantled flying fox, development of an enzyme-linked immunosorbent assay for detecting antibody responses in the Island flying fox, community led population monitoring of the Madagascar flying fox, population monitoring of Malayan flying foxes in the Philippines, the relationship between seeds, pollen, and forest regeneration by the Malagasy straw-colored fruit bat, and the Island Bats Conservation Initiative.

Vertical Stratification and Seasonal Patterns of Bats in a Neotropical Lowland Rainforest in Panama

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Neotropical bat communities are among the most complex and diverse. The exceptional diversity of Neotropical bats is mainly due to the diverse feeding ecology of phyllostomids, the most speciose family of bats in the Neotropics. Bats are of critical importance for pollination and seed dispersal, and are predators of insects and small vertebrates in tropical forests. Although temperatures in the tropics do not vary strongly, rainfall is seasonal and influences community dynamics strongly by regulating food and roost availability. I am studying the seasonality of species composition and abundance of the Neotropical bat community on Barro Colorado Island, Panama, a seasonal semi-deciduous lowland forest. I used high net walls and ground level nets to sample the bats throughout the forest strata in the wet and dry season. Many bat species are found throughout the vertical forest levels (*Artibeus jamaicensis*, *Dermanura* spp.), whereas some species are almost exclusively captured within a small vertical range (*Lophostoma silvicolum*, *Carollia castanea*). Several species show extreme seasonality in their occurrence and abundance, especially higher flying species (*Centurio senex*, *Phyllostomus discolor*). In contrast others are found throughout the year in similar numbers. A significant seasonal shift of foraging stratum was not found for any of the studied species.

Bat Surveys in North America: The Implications of Who is Doing What

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Why do biologists conduct surveys for bats? This simple question has not been formally addressed, yet the answers could suggest future work to tailor the methods used to conduct surveys and exploit the resulting data. Although each of us may have a notion as to the objectives of “the average bat survey” and who conducts it, these have not been quantified. In late 2003, I circulated a questionnaire aimed at assessing the most important objectives and spatial scales of bat surveys in North America. The questionnaire was circulated via e-mail to participants of the 2002 and 2003 NASBR, Western Bat Working Group, and Southeast Bat Diversity Network with instructions to forward to other interested parties that would not be reached via these channels. I received 415 responses from 45 U. S. states and 7 Canadian provinces or territories. The majority of respondents were employed by government agencies, had less than five years experience with bats, and had less than 20% of their professional responsibilities dedicated to bats. The three most important objectives identified for bat surveys in rank-order were to: 1) create a list of species in an area, 2) monitor presence or abundance of bats at a structure, and 3) determine presence of a single species in an area. Two important conclusions can be drawn from these results. First, although the NASBR annually convenes the top scientists in North America involved in the study of bats, its participants conduct only a small proportion of the actual surveys for bats each year. The majority of bat surveys are coordinated or conducted by biologists with relatively limited experience and even less time allocated to bat work. Hence my second conclusion: additional efforts aimed at increasing the effectiveness, efficiency, and relevance of bat surveys conducted by those outside the research community would help address important information gaps and ultimately improve prospects for bat conservation in North America.

Acquiring Representative Echolocation Calls: A Comparison of Hand-release Calls to those Recorded on Zip-line

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Species identification of free-flying bats from their echolocation calls requires comparison to a collection of calls produced by bats whose species has been determined through other means. In order to be useful, such calls must be representative of bats in free flight. Recording the echolocation of a bat as it is released from the hand (hand release) is the most commonly employed technique for obtaining reference calls. However, the success of this method is often poor as bats fly out of range of the detector microphone or produce calls not representative of free-flight. The tethered zip-line has been proposed as an alternative to hand release. The zip-line method involves attaching the bat to a monofilament line using elastic thread, thereby allowing a controlled flight path and providing a means to recapture the bat to record additional calls if desired. For the zip-line technique to be preferable to hand release, it must not only provide additional confidence that a call will be recorded, but must provide calls of comparable quality. We compared the two methods by recording calls using both methods from 160 individuals of 9 species. We then measured call parameters useful for species identification including characteristic frequency, minimum frequency, call duration, and call interval. We used a single call from each individual for each method and compared parameters using a paired *t*-test. We present these results, comparison to calls recorded in free-flight, and recommendations for use, by species, of each of these methods.

Physiological and Ecological Aspects of Roost Selection by Reproductive Female Hoary Bats (*Lasiurus cinereus*)

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Recent research on the roosting habits of temperate, forest-living bats has focused on species that use enclosed cavities while few studies have investigated roosting by foliage-living species, which are assumed to have more flexible roost requirements. Furthermore, while numerous studies have suggested that bats select roosts on the basis of microclimate, few have tested this hypothesis empirically and none have addressed the use of foliage roosts in this context. We used radio-telemetry to locate roost sites of reproductive female hoary bats (*Lasiurus cinereus*), and measured a variety of physical features of hoary bat roost trees for comparison with randomly selected non-roost trees. We also recorded ambient temperature and wind speed at roost and non-roost sites to test the hypothesis that physical features associated with foliage roosts provide energetically important microclimate benefits. Hoary bats selected roost sites on the southeast side of mature white spruce trees. Roost trees were more likely than random trees to be the same height as the surrounding forest canopy (as opposed to taller or shorter); roosts had a lower canopy cover facing out from the tree in the direction of the roost branch; and forest density was lower on the southeast side of roost trees. These physical characteristics of roosts seemed to have little effect on ambient temperature, but wind speed was significantly lower at roosts sites compared to opposite sides of the same trees (opposite sites), likely due to increased protection from prevailing west winds. Incorporating an estimate of convective cooling due to wind, we calculated daily predicted thermal energy expenditure for normothermic bats and found that roost sites resulted in highly significant energy savings (of up to 1.6 g of insects per day) relative to opposite sites. Our results provide direct evidence that bats select forest roosts on the basis of microclimate and suggest that roost requirements of foliage-roosting species are more specific than previously assumed.

A Maternity Colony of *Nycticeius humeralis* in Southern Michigan

Lisa Winhold, Emily Hough, Rodney Foster, and Allen Kurta, Eastern Michigan University, Ypsilanti, MI

In early August 2004, we discovered a reproductive colony of evening bats, *Nycticeius humeralis* (Vespertilionidae), in southern Lower Michigan. A post-lactating adult female was captured in a mist net over Black Creek, near Palmyra, Lenawee Co., on 7 August. We attached a radio-transmitter to the interscapular region and tracked the bat to a dying green ash tree, *Fraxinus pennsylvanica*, 170 m ESE of the net site. After counting 25 bats exiting the first night, we set nets around the roost tree to capture a few individuals and confirm the identification. We caught nine juvenile evening bats and one adult female. We recorded measurements, collected parasites, attached a transmitter to a 10.0-g juvenile male, and released the bats. The two individuals with transmitters were tracked to two new trees. The adult female flew to a dead green ash, in the floodplain of Black Creek 340 m SSE of the original roost tree. The juvenile was tracked to a dying sycamore, *Platanus occidentalis*, on the bank of the River Raisin 780 m ENE of the original roost tree. Sixty-six individuals exited the three roost trees combined on 10 August. The bat caught on 7 August was only the fourth record of *N. humeralis* in Michigan, and the first since 1969. This maternity colony is the first in the state, and the northernmost reproductive colony for the species in North America.

Roost Selection and Foraging Movements of Peters' and Walhberg's Epauletted Fruit Bats in Kruger National Park, South Africa

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We used radio-telemetry to monitor the roosting and foraging behaviors of six *Epomophorus wahlbergi* and two *E. crypturus* in Kruger National Park, South Africa. Sample sizes for eight bats ranged from 13 to 168 positions (mean = 68). The tracking period, May 31 to July 2, 2004, was during the dry season. Although males were occasionally heard calling, only females were captured. Both species foraged extensively in fig trees and both were netted in fig trees. We found no other appropriate fruits in Kruger during this study. There were two study sites. At Skukuza Camp five *E. wahlbergi* and one *E. crypturus* were captured by netting at the day roosts. Both species roosted together under the thatched roofs of buildings. Three roost groups varied in size from 3 to 30 individuals. Space was not limiting, and individuals were always separated by several cm. Emergence from the day roost varied from 1830h (dusk) to 2300h. Preliminary inspection of the data suggests that these bats had elliptical home ranges with long axes up to 700 m. We speculate that both delayed emergence and small home ranges result from the abundance of fruiting fig trees along the Sabie River, within 100 m of the day roosts. Individual bats often returned to the day roost site between night-time foraging bouts, but also night-roosted in large trees of several species (including *Ficus*). At Shingwedzi one *E. wahlbergi* and one *E. crypturus* were captured in a canopy net set in a large fruiting *Ficus sycomorus*. Twice these individuals were tracked to the same day roosts in Common Spikethorn and Mopane shrubs, respectively. Figs were restricted to the banks of rivers here, and these bats had home ranges along the Shingwedzi River that were approximately 3-4 km long.

Learning and the Development of Plastic Echolocation
Matthew A. Wund, University of Michigan, Ann Arbor, MI

Many generalist bat species exhibit adaptive plasticity of echolocation calls when they use habitats that differ in structural complexity. In this experiment, I tested the hypothesis that learning is necessary for the development of this call plasticity. I recorded the echolocation calls and insect detection success of 14 juvenile little brown bats (*Myotis lucifugus*) as they foraged repeatedly in a large flight tent. As bats gained experience, their detection performance improved considerably in both open and spatially complex habitat treatments. This improvement was statistically related to changes in echolocation call structure from trial to trial within each habitat type. This result is consistent with the hypothesis that bats learn to improve their calls in each habitat they encounter. Once the developmental mechanisms giving rise to adaptive call plasticity are better understood, hypotheses regarding how selection acts to shape plastic traits, and any learning associated with their development, can be tested thoroughly.

An Ecomorphological Analysis of the Genus *Carollia* (Phyllostomidae)
Heather A. York and Monica Papes, University of Kansas, Lawrence, KS

The four well recognized and long-established species of *Carollia* (Phyllostomidae), *C. brevicauda*, *C. castanea*, *C. perspicillata*, and *C. subrufa*, are relatively widespread throughout the New World tropics and generally are considered to be ecologically very similar. However, recent taxonomic reexamination of the genus resulted in the recognition of new species and emphasizes the importance of considering potential ecological differences among species, subspecies, and populations within the genus. To examine the extent to which ecomorphological traits parallel taxonomic and geographic divisions within *Carollia*, we measured skull length, skull width (mastoid breadth), width of orbital constriction, length of toothrow, maximum mouth width, and length of forearm on 1910 museum specimens of *Carollia* from throughout Central and South America. Locations of capture were recorded from these specimens and were georeferenced to generate exact latitude and longitude, for which a series of environmental data was extracted from GIS layers. Elevation, mean diurnal temperature range, average daily maximum, minimum, and mean temperatures, average annual precipitation, mean annual number of rainy days, and average vapor pressure were found for each locality and attributed to each specimen. These morphological and environmental measures were compared across various groups within the genus: species and subspecies, Central and South American populations, and sexes within a species. Overall results suggest that most groups differ significantly in body size, skull size, and mouth size as well as in the shape of the skull and mouth. Similarity in size and shape are most common among groups that occur in allopatry, suggesting that sympatry plays a role in driving morphological differentiation within the genus (or, alternatively, that morphological distinctness has facilitated sympatry among various populations). Furthermore, we found strong evidence of sexual dimorphism within the various species; males tend to have larger skulls while females have longer forearms. Differences in environmental preferences also exist among the groups of *Carollia*, but they do not highlight clearly any taxonomic or ecological divisions. Our findings indicate that the various groups of *Carollia* may be environmentally robust, therefore potentially allowing them to occupy similar habitats, at the same time that morphological differentiation exists that may render them distinct from one another in foraging behavior, food preferences, and the extent to which they are dietary generalists or specialists.

Leveraging Informal Networks: Research/Conservation Partnerships

Missy F. Young, Lisa J. Roberts, Christopher M. Quick, and Sarah N. Gatson, Texas A&M University, College Station, TX

Beginning in the summer of 2003, our lab has been part of a team (QuickLab) that has reintroduced the pallid bat (*Antrozous pallidus*) wing as a model for vascular networks, specializing in investigating the long- and short-term microvascular adaptations of vessels. In the spring of 2004, this team expanded its efforts into a research and teaching protocol identified as "The eBat Project." By developing an informal network, this has increased the unique resources of QuickLab with the use of an Internet interface, the lab's experimental equipment, and the pallid bat. QuickLab and eBat seek to break down the mistrust and hostility between two communities that offer benefits to the scientific community of researchers and conservationists (wildlife ecologists, biologists, etc). Currently, these two loosely-defined groups are like oil and water. Primary researchers have to use animals, but because of legitimate fears and conflicts with the conservationists, they rationally protect themselves and their work by not publicly posting their data, or their discussions and explanations of the benefits of their research. Therefore, no outsider knows the protocols, particularly the mandate to reduce the use of live animals and the husbandry that actually takes place in a laboratory animal care facility. Simultaneously, animal advocates and the expertise they have with the natural environments and needs of particular animals are not always seen as a resource by university animal researchers. These advocates have practical insights and experience for fulfilling research animal use protocols; the minimization of pain, animal enrichment, and the maintenance of chronic animal populations. Maintaining our chronic bat colony is due to the experience of QuickLab, the informal networks of our primary research assistant, and groups such as Bat Conservation International (BCI). Just as BCI strives to protect and conserve the image of bats, so can QuickLab rehab the image of research animal use, and in our site, the two goals merge. We must protect and conserve the natural colony in order to maintain the lab colony. Formation of the lab, and how the lab will itself evolve both as a practical research environment, and as a model for other such research/conservation partnerships, focuses on the networks of the people involved, and the informal and horizontal structure of the lab. With continued efforts to sustain these informal networks, we can set the framework for other partnerships to form within the scientific community and advance scientific knowledge through research.

Developing a New Forest Bat Survey Protocol: Strategic Decisions to Achieve Multiple Objectives

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The population status of most bat species is poorly understood, yet biologists are increasingly called upon to determine the occurrence of individual species or to describe a bat community that may be affected by management activities. Numerous sources of information about survey methods are available but each lack standards for consistent application and clear direction for a variety of objectives. The North American Bat Conservation Partnership and the Western Bat Working Group (WBWG) consider the development of a new protocol with these objectives a priority. The WBWG formed an Inventory and Monitoring Subcommittee whose main goal is to develop a manual to standardize methods for bat inventories in western North America. Not only would standard methods improve the quality of data at individual sites but, treated collectively, the results of individual surveys can help address questions about distributions, migration routes, and regional-scale habitat associations. The challenge is to provide guidance to detect species that is prescriptive enough to be useful yet flexible enough to be widely applicable. Results of a recent questionnaire indicate that a large number of bat surveys are conducted in forests with the goals to either determine the species that occur in a specified area or to document the species that use a specific site. To meet these needs the guide will contain two primary protocols: the Area Protocol and the Site Protocol. The Area Protocol responds to the need to develop a credible list of bat species that occur in areas that vary in size. This method recommends surveys that sample the habitat and structural features that are attractive to bats. It is a 2-phase protocol that prescribes a primary approach that will detect the majority of common species followed by a strategic second phase that uses information provided in the manual to target species that are presumed to occur in the area but have not yet been detected. The Site Protocol describes the methods used to determine the bat species that occupy a single cave, mine, bridge, or building. We apply our knowledge of sampling at multiple scales and spatio-temporal variation in habitat use by bats to recommend the level of effort suitable for inventories at scales ranging from a single feature to an ecoregion. The work of the subcommittee represents a unique opportunity to translate the widespread call for a standard survey method into a viable tool for the conservation of forest bats.

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Report on the
34th Annual North American Symposium on Bat Research

by
Margaret A. Griffiths, Program Director, NASBR

The 34th Annual North American Symposium on Bat Research was held at the Little America Hotel in Salt Lake City, Utah, 27-30 October 2004. Michael Herder (Bureau of Land Management Arizona Strip) served as the local host, and was assisted by his local committee (Keith Day, Kate Grandison, Tom Haraden, Adam Kozlowski, Mark Mesch, Missy Siders, John Taylor, and Vicki Tyler). Three hundred registered participants attended the three-day scientific conference, making this the largest non-international meeting ever held. In addition to the regular participants, there were approximately 20 local educators who attended the special Bat Education Workshop on Saturday morning.

Most of the meeting participants were affiliated with academic institutions (60.7%); 21.0% were from federal or state government agencies; 13.0% were from private business or private consulting groups; 2.65% were from non-governmental zoos and parks; and 2.65% were individuals who attended simply because they were interested in bats. More than a third (38.0%) of the meeting participants were students. The majority of NASBR participants were from North America: 87.3% from the United States, 6.0% from Canada, 1.7% from Puerto Rico, 1.0% from Mexico, and 0.7% from Costa Rica. Three percent of the participants were from Europe (Germany, 1.3%; Switzerland, 0.7%, United Kingdom, 0.7%; and Austria, 0.3%), and one member (0.3%) was from American Samoa .

One hundred and fifty one scientific papers were presented at the Salt Lake City meeting, not counting the seven special presentations given during the Saturday morning workshop for local teachers. Of the 151 scientific papers presented, 95 were platform presentations and 56 were poster presentations. Thirteen student platform papers were presented in a plenary Student Competition Session on Thursday morning and early afternoon. Concurrent sessions began on Thursday afternoon and continued through Saturday afternoon. This was the first non-international meeting to have concurrent sessions on the first day of the conference, reflecting the increased number of papers being submitted to the NASBR. Fifty-six posters, eight of which were entered in the Student Poster Competition, were presented during the Friday afternoon Poster Session. Two special scientific sessions, Agroecology and Phylogeny & Bat Diversity, also were held during the 3-day conference.

During the Saturday business meeting, the NASBR Board of Directors presented a resolution on bats and rabies to the membership. After much lively discussion and revision of the resolution, it was adopted by the membership. The resolution can be found on page 290 of this issue of *Bat Research News* (Vol. 45: No. 4) and also on the NASBR web site at: http://www.nasbr.org/Resolutions.html

Graduate and undergraduate students were invited to enter their platform or poster papers in a competition that judged the scientific merits of their research presentations. A special committee headed by Frank Bonaccorso judged 13 student platform papers and 8 student poster presentations. Five cash prizes of $250 each and a special Speleobooks merchandise prize were presented at the Saturday night banquet. The award winners for outstanding platform papers were: **Daniel K. Riskin** (Cornell University, Ithaca, NY) received the Bat Conservation International Award; **Gerald G. Carter** (Cornell University, Ithaca, NY) received the *Bat Research News* Award; **Hugo Mantilla-Meluk** (Texas Tech University, Lubbock, TX) received the Karl F. Koopman Award; and **Polly Campbell** (Boston University, Boston, MA) received the Lubee Bat Conservancy Award. **Kate P. Ingram** (University of Nevada, Reno, NV) received the Basically Bats Wildlife Conservation Society Award, and **Jonathan Reichard** (Boston University, Boston, MA) received the Speleobooks Award for outstanding poster presentations. Generous monetary donations from Merlin Tuttle of Bat Conservation International, Roy Horst and Margaret Griffiths of *Bat Research News*, Roger and Sherry Haagenson and Allyson Walsh of Lubee Bat Conservancy, the Board of Directors of Basically Bats Wildlife Conservation Society, and Emily Davis and Michael Warner of Speleobooks made five of the prizes possible. Donations from numerous individuals made the Karl F. Koopman Prize possible.

Another highlight of the banquet was the presentation of the Gerrit S. Miller, Jr. Award to Rodrigo Medellín of the Universidad Nacional Autónoma de México, Instituto de Ecologia, Mexico. The Gerrit Miller Award is presented to persons "In recognition of outstanding service and contribution to the field of chiropteran biology," and is NASBR's highest honor. Rodrigo joins a small group of distinguished individuals who have received this prestigious award.

Pat Morton of Texas Parks and Wildlife once again organized a special bat education workshop on Saturday morning of the conference. Salt Lake City-area educators attended the workshop, as well as many NASBR members. This was the ninth consecutive year that Pat has organized this workshop in conjunction with the annual NASBR. Thank you, Pat, for your efforts in making the annual workshop possible. We also thank Bat Conservation International, Lubee Bat Conservancy, Organization for Bat Conservation, *Bat Research News*, Speleobooks, Indigo Wings, and Texas Parks and Wildlife for their generous donations to support the workshop.

I thank Mike Herder, his local committee, Al Kisner, and Donna Mathisen for all their help in Salt Lake City. I also thank the 2003-2004 Board of Directors (Robert Barclay, Frank Bonaccorso, Mark Brigham, Betsy Dumont, Trish Freeman, Michael Herder, Winston Lancaster, Arnulfo Moreno, Dixie Pierson, Roy Horst, and Tom Griffiths) and the Student Observer to the Board (Annie Tibbels) for their help and support this year. Additionally, I extend a very special "thank-you" to Jason Callard, Nikki Taylor, and Tom Griffiths for all their help and hard work to make the 34th NASBR a very memorable and successful meeting.

And finally, on behalf of the entire NASBR membership, special thanks from all of us to Roy, the "founding father" of the society, and, of course, to the bats!

See you in Sacramento, California!

9th Annual Teacher's Workshop
Held in Salt Lake City
30 October 2004

by
Pat Morton, Workshop Organizer
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For the past nine years, NASBR has hosted a teacher's workshop in conjunction with the annual meeting, as a form of community outreach for the city where the NASBR is held. Each year I recruit a faculty of NASBR members and local talent from the region, and this year, seven people gave up part of Saturday to help with this important activity. Join me in saluting these special individuals: **Mike Bogan**, U.S. Geological Survey (New Mexico); **Stephen Burnett**, Clayton College and State University (Georgia); **Meg Goodman**, Texas Parks and Wildlife Department (Texas); **Apple Snider**, Organization for Bat Conservation (Michigan); **Vicki Tyler**, U.S. Forest Service (Utah); **Allyson Walsh**, Lubee Bat Conservancy (Florida); and **Dharma Webber**, California Bat Conservancy (California). Presentations covered a review of regional bats, along with demonstrations of classroom activities and curricula dealing with bats. In previous years the Organization for Bat Conservation (Michigan) exhibited a selection of Old and New World species, but this year, because the meeting was in the West, Dharma Webber brought bats (with permits) from California. Caring for these live animals is around-the-clock work, and we are very grateful for the extra effort to provide the excitement of introducing educators to live animals.

Finding willing presenters is only part of the recipe for a successful workshop, and we also depend on our much appreciated sponsors. For many years we have received regular monetary and in-kind donations from the **Lubee Bat Conservancy**, **Bat Conservation International**, **Organization for Bat Conservation**, **Speleobooks**, ***Bat Research News***, and **NASBR**, and this year we received our first sponsorship from the **California Bat Conservancy**. These valued donations provided each participant with a collection of classroom materials, including videos, books, curricula, posters, and bat-related door prizes. Finally, the workshops could not happen without help from several other individuals: **Michael Herder**, local host of the 34th NASBR; **Margaret Griffiths**, annual miracle worker; and **Barbara Ogaard**, master volunteer.

In 2005, the Teacher's Workshop will celebrate its 10th anniversary at the 35th Annual NASBR meeting in Sacramento, California. With all the interest already received, I know it will be an exciting workshop. **Winston Lancaster** (local host) and I have already started planning. Please contact me if you can help with a presentation, assist at the workshop, and/or provide a donation.

Resolution Concerning Bats and Rabies
adopted by the NASBR membership at the
34th Annual North American Symposium on Bat Research
October 2004

Be it resolved on this 30th day of October 2004 that researchers gathered at the 34th Annual North American Symposium on Bat Research are concerned about public misperceptions regarding undetected bites from bats, and the negative consequences for bats that are generated by those misperceptions.

Cases of rabies in humans in the United States and Canada are extremely rare. Data from the U.S. indicate that most human rabies infections occur because victims are bitten and either do not realize the risk of being bitten or trivialize the wound. No animal bite should be trivialized.

In our collective experience, bat bites cause sufficient pain to be readily detected, and if bitten by a bat, people will be aware of the bite. However, under certain circumstances (e. g., deep sleep, intoxication, illness or mental incapacity, or being a child too young to recognize or relate the history of exposure), the minor trauma and wound may not be recognized as a bat bite and could also go untreated.

We are concerned that people receiving bat bites sometimes do not seek medical attention. We are also concerned that the media and local public health agencies frequently overreact to incidental bat exposure, causing unnecessary eradication of bats or treatment of people not bitten by bats. This results in actions and public perceptions that are costly to people, detrimental to bats, and provide no additional protection against rabies.

We support:

1) education efforts regarding the human health risks associated with bat rabies that reflect the best scientific evidence available

2) scientific and epidemiological reports and guidelines that are written to be easily understood by the average person, and

3) continuing efforts to develop a national database of rabies exposures, treatments, and outcomes.

We recognize the need for reasonable precautions against rabies. We support public education about bats and rabies that:

1) cautions to never handle bats or other wild animals;

2) warns to practice appropriate first aid measures and seek immediate medical evaluation, which may include post-exposure prophylaxis, of any actual or suspected animal bite; and

3) places the risks of human infection in perspective, without trivializing the serious nature of the disease.

FUTURE MEETINGS and EVENTS

February 2005
Annual meetings for the Colloquium on the Conservation of Mammals in the Southeastern United States and the Southeastern Bat Diversity Network (SBDN) will be held in February 2005 at Paris Landing State Park in Tennessee (**http://www.state.tn.us/environment/parks/parks/ParisLanding**/). More information will be available on the SBDN website (**http://www.sebdn.org**)

March 30 - April 2, 2005
The 2nd Biennial Meeting of the Western Bat Working Group will be held on March 30 - April 2, 2005 in Portland Oregon. The conference offers the opportunity for biologists and managers with interest in or responsibility for bats the opportunity to exchange information and ideas regarding ecology and conservation of bats in western states and provinces. Information is available at: **http://www.wbwg.org/portland.htm**

July 31 - August 4, 2005
The 2nd Ouachita Mountain Bat Blitz will focus on the Poteau, Cold Springs, and Fourche Ranger Districts located in the northwest Arkansas portion of the Ouachita National Forest bordering the Arkansas River Valley. Base of operations will be Rogers Scout Reservation (RSR) in Ione, Arkansas, just off AR State Highway 23 in Logan County. To receive Blitz updates and registration information, contact Frances Rothwein at 479.675.3233 or by e-mail: **frothwein@fs.fed.us**

July 31 - August 5, 2005
The 9th International Mammalogical Congress will be held in Sapporo, Japan, and will include a symposium on "Ecology and Conservation of Bats in the Pacific Rim." For information about presenting at the bat symposium, please contact: **funakoshi@int.iuk.ac.jp** Additional information about the symposium and Congress is available at: **http://www.imc9,jp**

August 21 - 26, 2005
The 10th European Bat Research Symposium will meet in Galway, Ireland. The convenor, Jimmy Dunne, is currently putting information together and establishing a web site. Details will appear here as they become available.

October 17 - 19, 2005
The Western Section of the Wildlife Society is sponsoring a comprehensive "Natural History and Management of Bats in the West" Symposium in Sacramento, CA, October 17-19, 2005. Join Patricia Brown, Elizabeth Pierson, and many other recognized experts for lectures on ecology, conservation, behavior, survey methodology, habitat evaluation and status of most western bat species. Two full days of presentations are included (over three days). Additional information will be available soon, and registration begins in July at: **www.tws-west.org**

October 19 - 22, 2005
The 35th Annual North American Symposium on Bat Research will convene in Sacramento, CA, October 19-22, 2005. Winston Lancaster will host the Symposium. For additional information see our web-site at: **http://www.nasbr.org/** or contact Margaret Griffiths: **mgriff@illinoisalumni.org**

October 18 - 21, 2006
The 36th Annual North American Symposium on Bat Research, will convene in Wrightsville Beach, NC, October 18-21, 2006. Mary Kay Clark will host the Symposium. For additional information see our web-site at: **http://www.nasbr.org/** or contact Margaret Griffiths: **mgriff@illinoisalumni.org**