BAT RESEARCH NEWS

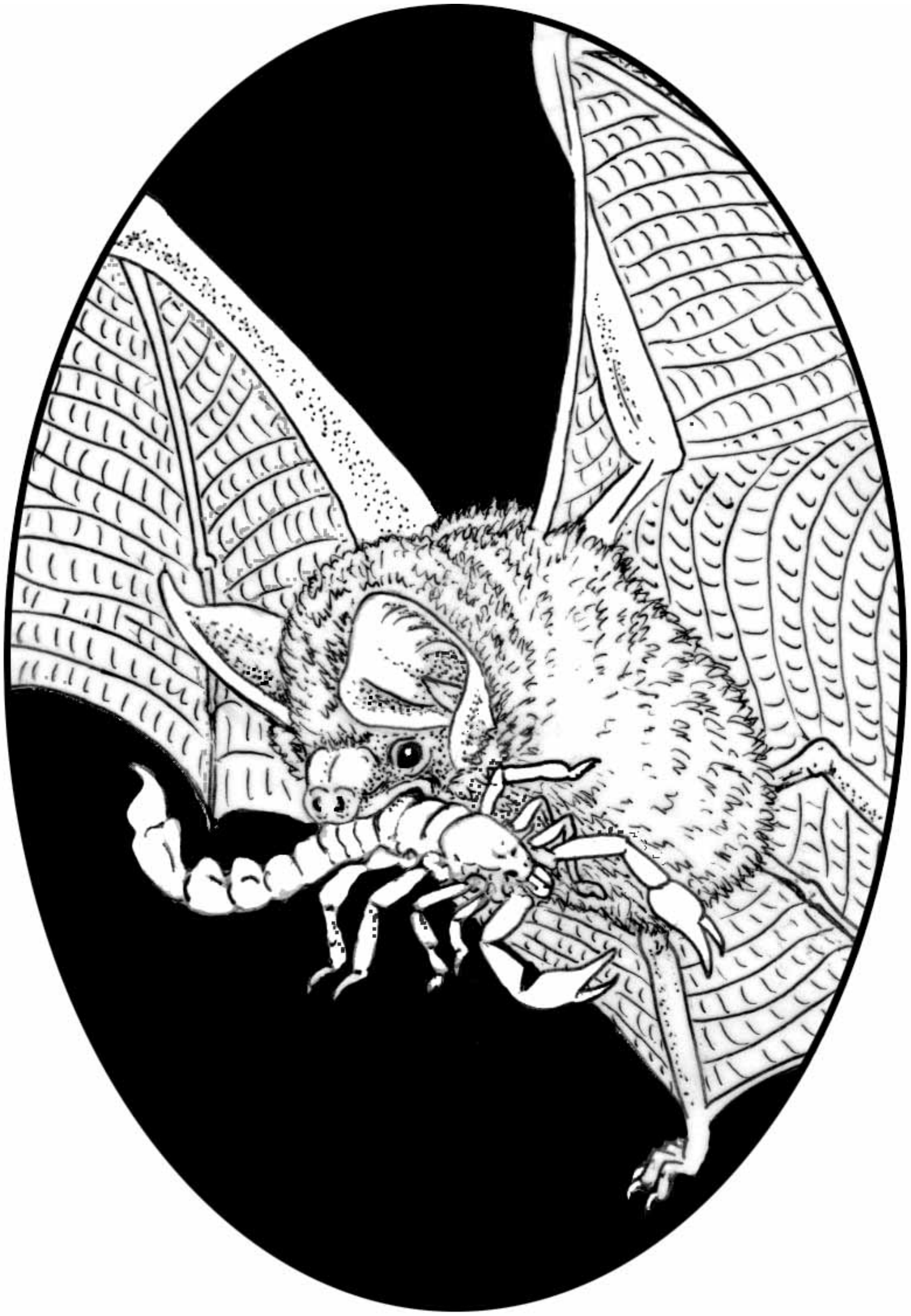

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Table of Contents for Volume 46, 2005

Volume 46: Number 1, Spring 2005

Volume 46: Number 2, Summer 2005

Volume 46: Number 3, Fall 2005

Volume 46: Number 4, Winter 2005

BAT RESEARCH NEWS

VOLUME 46: No. 1 **Spring 2005**

Table of Contents

Front Cover

The front cover illustration is a portrait of *Antrozous pallidus* by Fiona Reid of Toronto, ON. This drawing of the pallid bat is copyrighted by the artist, and is used with her generous permission. Thank you, Fiona.

The Use of Bat Gates at Abandoned Mines in Colorado

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Introduction

Availability of roosts affects the distribution and viability of most nearctic populations of bats (Humphrey, 1975; Pierson, 1998). Bats find suitable roosting habitat in various natural and man-made features, including trees, rock crevices, caves, buildings, and mines. Subterranean roosts are used occasionally by many species, but some species are dependent on these features for all or some of their seasonal roosting requirements (e.g., Humphrey and Kunz, 1976; Kunz and Martin, 1982). Abandoned mines often serve as surrogates for caves and recently have received attention in efforts aimed at bat conservation (Navo et al., 1991; Riddle, 1995; Tuttle and Taylor, 1998; Vories and Throgmorton, 2000).

One tool available to resource managers for protection of caves and mines is a "gate" (Currie, 2002; Vories et al., 2002), which restricts access by humans and eliminates disturbance to roosting bats. Gates, when properly designed and constructed, can aid in the recovery of bat populations at formerly impacted roosts (Richter et al., 1993). However, improperly designed gates can have negative impacts on bats, including abandonment of roosts (Tuttle 1977) and alteration of internal microclimate (Currie, 2002; Richter et al., 1993). Additionally, bat gates may alter normal patterns of flight at cave entrances or increase predation (Hammer and Arlettaz, 1998; Ludlow and Gore, 2000; Tuttle, 1977; White and Seginak, 1987).

Gate designs have changed over the years to increase their resistance to vandalism and reduce impacts to air movement and subsequent modification of internal temperature (Currie, 2002). Current designs are used successfully at some North American caves and mines that harbor large colonies of bats, such as gray bats (*Myotis grisescens*) and Indiana bats (*Myotis sodalis*), but their construction can be expensive and difficult to justify with smaller colonies or species not known to be endangered or declining. In some western states, bats often use abandoned mines, but colonies typically are smaller (Sherwin et al., 2000a, 2000b; Sherwin et al., 2003) than those in the East (Currie, 2002; Ducummon, 2000). Resource managers, with limited funds and many pressing issues, need alternative designs to aid in conservation of bat roosts at abandoned mines in the West. However, it is important to include a monitoring program with implementation of new designs to evaluate the effectiveness of the design and resultant success of the conservation action (Currie, 2000; Burghardt, 2000).

In Colorado, protection of bat roosts in abandoned mines began in 1990 (Navo et al., 1991). Species using abandoned mines in Colorado include *Antrozous pallidus*, *Corynorhinus townsendii*, *Eptesicus fuscus*, *Myotis lucifugus*, *M. volans*, *M. evotis*, *M. thysanodes*, *M. ciliolabrum*, *M. californicus, Pipistrellus hesperus*, and *Tadarida brasiliensis*. The focus of gating efforts, however, is *C. townsendii*, a species that is declining over much of its range (Perkins, 1985; Pierson et al., 1999). To reduce the cost of gates and increase the number of mines that are protected, modifications of standard designs were developed and installed during mine reclamation activity from 1991 to 2004. Herein, we report the results of 13 years of post-construction monitoring on these designs and their implications for conservation of bat roosts in abandoned mines of the West.

Methods

We evaluated four types of gate—full gates, ladder gates, culverts with full gates, and culverts with ladder gates (Fig. 1)—mostly at sites with evidence of use by *C. townsendii*. Full gates are the traditional design and provide for passage of bats across the entire gate (Vories et al., 2002). Some full gates were constructed of flat iron bars instead of the standard angle iron. The ladder design (Navo and Krabacher, 2002) was similar to that reported in Pierson et al. (1991), with the center of the gate designed to allow bat passage and the sides allowing airflow only. The entire gate was welded to steel anchors secured into the surrounding bedrock. Occasionally, the ribs (sides) of a mine were weathered or otherwise too unstable for anchoring the gate, and in these cases, a steel culvert (<6 m in length) was placed in the portal; the gate then was welded to the culvert, or mortared rock walls were keyed into the sides to provide a secure anchoring for the gate. These "wing walls" did not interfere with airflow, because the face of the walls was at the excavated side of the adit and did not constrict the opening of the mine. Spacing between bars in a full gate or the center of a ladder gate was 15 cm (6 inches).

Gated mines were located throughout central and western Colorado. Elevation of the mines ranged from ca. 1,750 to 3,600 m, and surrounding forests included pinyon-juniper, ponderosa pine, mixed conifer, and spruce-fir woodlands; most mines were in pinyon-juniper/desert shrub or mixed conifer habitats. Four types of bat-friendly closures were monitored, including 28 ladder gates, 8 full gates, 6 culverts with ladder gates, and 5 culverts with full gates.

Our post-gating surveys documented only whether or not bats were using the mines and not whether the size of the population changed after gating. Surveys were conducted using a variety of techniques, including capture of bats at entrances, internal surveys, and passive monitoring. Surveys at the portal of a gated mine involved harp traps and were intended to document use of a gate by the capture of bats going in or out of the mine; all captured bats were identified to species, aged, sexed, and released. Internal surveys involved actually entering a gated mine to document roosting bats and followed standard safety guidelines (Altenbach, 1995; Navo, 2001). Most passive surveys used video cameras (Sony, Handycam Nightshot Digital 8, DCR-TRV120; Sony Corp. of America, New York, New York), but as an additional evaluation for some ladder gates, an infrared motion detector (Trailmaster 1500, Goodson & Associates, Inc., Lenexa, Kansas) was installed on the inside to document passage of bats.

Number of surveys conducted at a single mine ranged from one to ten, and some sites were monitored using multiple methods. Time between pre- and post-gating surveys was 1–12 years. Average time between installation and initial evaluation was 1.6 ± 0.2 (*SE*) years and ranged from <1 to 5 years.

Results

During 13 years of reclamation activities, 330 gates were installed at 295 mines. We selected 47 mines for 89 post-gating surveys that occurred from June 1992 to July 2004. Post-gating monitoring consisted of 58 capture surveys, 22 internal surveys, and 9 video surveys; in addition, use of five mines was further evaluated with a motion detector. We documented

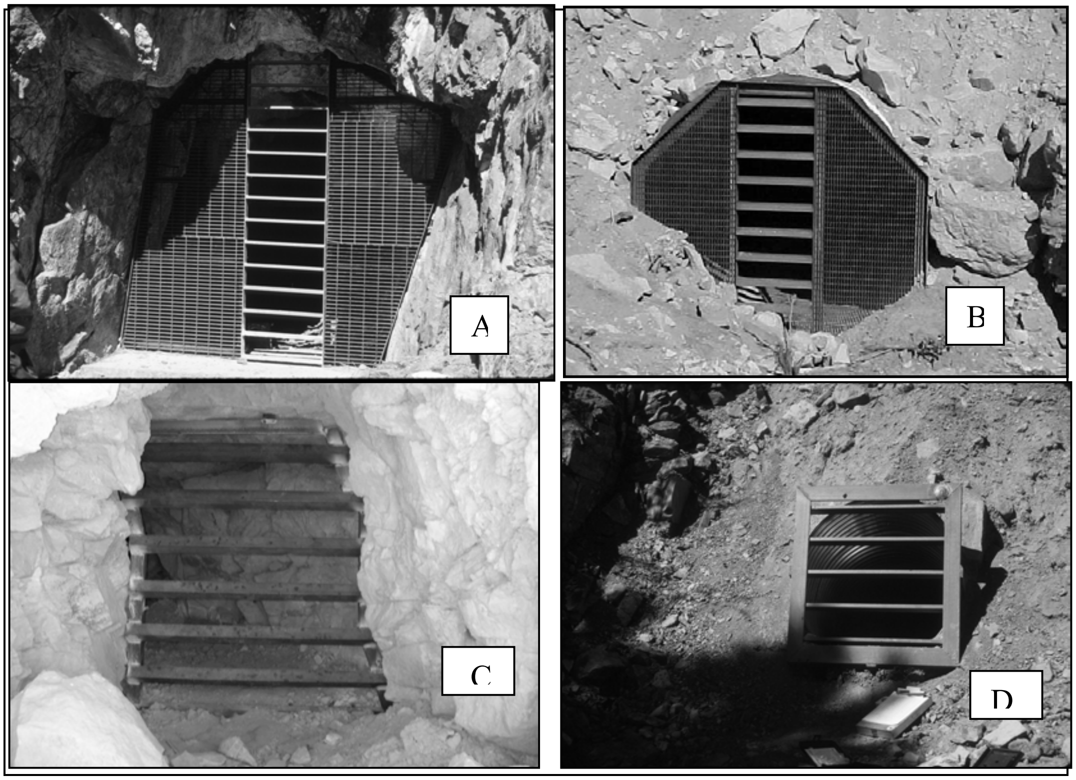

Figure 1. Styles of gate used at mines in Colorado. A) ladder, B) culvert with ladder, C) full, and D) culvert with full.

continued use by bats at 43 mines (91%; Table 1), and of the four mines at which we failed to document bat use, three received only one post-gating survey. All video surveys indicated positive results (i.e., continued presence of bats); similarly, 95% of internal surveys and 88% of capture surveys yielded positive results. Overall success rate for the various designs of gates was 89–100%.

Eight species of bats used gated mines (Table 2). Although all styles of gate allowed some use by bats, *C. townsendii*, *E. fuscus*, *M. thysanodes*, *M. californicus*, *M. ciliolabrum*, and *M. volans* were the species that used all basic types of gates (ladder, full, culvert). *C. townsendii* roosted at 41 sites initially, and 35 (85%) continued to be used by this species after gating; 20 of 24 (83%) roosts of *C. townsendii* that received ladder gates had continued use. Gates were successful at all types of roosts of *C. townsendii*, i.e., hibernacula, summer roosts, and maternity sites. Although gates were placed at only seven maternity roosts, all seven sites had evidence of post-gating use. One ladder gate had continued bat use 12 years after gating. Gate designs at maternity roosts included three mines with full gates at the largest colonies (>100 bats), three ladder gates at intermediate-sized colonies (30–75 bats), and a culvert with a full gate at a small colony (<12 bats).

Eighteen sites had multiple (2–9) post-gating surveys that were conducted 1–12 years after gating. All these sites continued to provide roosting habitat, some for up to 12 years after installation of a gate. Seventeen mines with multiple surveys were roosts of *C. townsendii*, and all types of gates showed continued use by this species: ladder gates (11), full gates (2), culverts with ladder gates (2), and culverts with full gates (2). Another mine with a ladder gate had three

Table 1. Summary of post-gating monitoring at mines in Colorado

Type of gate	*Number of mines evaluated*	*Number of mines used*	*Percent success (%)*	*Number of Surveys*
Full	8	8	100	12
Culvert/full	5	5	100	15
Culvert/ladder	6	5	83	8
Ladder	28	25	89	54
Total	47	43	93	89

Table 2. Number of gates of various types with confirmed use by species

Species	*Full gate*	*Culvert with full gate*	*Culvert with ladder gate*	*Ladder gate*
C. townsendii	8	4	3	20
E. fuscus	3	2	0	1
M. californicus	2	1	0	3
M. ciliolabrum	2	2	1	7
M. evotis	0	1	0	2
M. lucifugus	0	0	0	3
M. thysanodes	1	1	0	3
M. volans	0	2	0	9
Undetermined[a]	0	2	2	2

[a] Undetermined hibernating *M. californicus* and/or *M. ciliolabrum*.

surveys conducted over 10 years, and the site continued to be used by *M. volans*, *M. evotis*, and *M. lucifugus* as a roost in summer and fall.

Discussion

Monitoring indicates that most types of gate are accepted by at least some bats, and overall, 43 of 47 gates continued to allow use by bats (Table 1). Although four mines had no evidence of continued use, three had received only one post-gating survey. Ladder gates in particular appear to be well received (Table 2) by most species of bat roosting in abandoned mines in Colorado—at least in terms of continued use. We documented eight species flying through the ladder-gate design in Colorado. Of 28 ladder gates, bats continued to use 25, with use at some sites occurring up to 12 years after gating. Although continued use did not occur at three ladder gates, one was a high-elevation mine above 3,000 m, and only *M. volans* uses these high-elevation mines on an irregular basis. In addition, recent studies indicated that use of roosts by *C. townsendii* is variable within seasons and among years (Sherwin et al., 2000a, 2000b, 2003), and multiple post-gating surveys may be required before use can be documented.

Both types of culvert-style gates also were well received by bats, with eight species using 10 of 11 of these types of gates, for up to 8 years after gating. All successful culvert gates, except one, had diameters that closely retained the dimensions of the original portal, and all were <6 m in length. Only one survey was conducted at the culvert with a ladder that did not document bat use. This was a fall roost site, and because of the inconsistency of fall roosting by bats, the apparent lack of use could be due to chance.

Although few gated mines were accessible for internal winter surveys (17), all four types of gate continued to support hibernating bats, suggesting that these designs did not adversely change internal microhabitat and that bats were able to navigate all designs. Bats arrive and leave winter roost sites under less crowded conditions than at summer roosts, and the reduced traffic may allow some western species, especially *C. townsendii*, to tolerate better the restricted entrances.

Corynorhinus townsendii continued to use most ladder-gated mines, indicating that design and construction of this type of gate did not significantly change microhabitat or impede light-sampling behavior. A similar ladder design was successful for big-eared bats in California (Pierson et al., 1991). Additionally, we documented *C. townsendii* using all types of gates, suggesting that big-eared bats apparently have a high degree of tolerance for flying through restricted openings. This seems especially true at fall transition roosts and hibernacula. Only seven gated sites contained big-eared bat maternity colonies, and therefore, different types of gates should be evaluated further before widespread use occurs at maternity roosts.

Many mines used as roosts in the East are occupied by large colonies, often consisting of thousands of individuals (Currie, 2002; Tuttle and Taylor, 1998). However, mines in Colorado, like other western states (Sherwin et al., 2000a, 2003), typically provide roosting habitat for a smaller number of bats. Number of bats passing through a gate is an important consideration, and some designs used in our project likely would not be accepted by larger colonies. Large colonies roosting in mines should be provided with full gates, at least until further research can be undertaken.

With the exception of perhaps some colonial species in the Southwest (e.g., *Leptonycteris* and *Macrotus*), we recommend that abandoned mines used as summer roosts in the West be protected by use of ladder- and full-style gates, because these seem conducive to use by a number of western species. Mines providing winter roosts can be gated with various designs, provided there are not large numbers of hibernating bats. Culvert designs can be used successfully at mines with unstable portals; however, to minimize potential airflow changes, culvert diameter should closely match original dimensions of the portal. Additionally, to maximize the size of available fly-ways through the gate and decrease potential risks of predation, a full gate should be used on the end of the culvert when culvert diameters are less than 6 ft (2 m).

Reclamation schedules and funding restrictions precluded our ability to evaluate changes in the size of the population of bats using various mines during our post-gating monitoring. Therefore, our results should be viewed with caution, because without pre- and post-gating population assessments, it is unknown if bat populations using these gates were increasing, decreasing, or stable. Although our overall results are promising, more rigorous research is required to evaluate change in size of a population, survivorship, and rate of predation, as well as potential changes in microhabitat induced by various designs. Like most issues concerning management of natural resources, conservation of bat roosts in abandoned mines will require continual assessment and adjustment, because resource managers operate in a limited-funding and time-constrained environment. Although modifying the design of gates is potentially risky, the alternative of fewer gates is a less favorable option. The safeguarding and reclamation of abandoned mines will not wait until we obtain all our answers, and managers always have the option of retrofitting gates that do not function as intended, as revealed by post-gating monitoring.

Acknowledgments

We thank the field managers of the inactive mines program of the Colorado Division of Minerals and Geology for their partnership and insights into bat gates in Colorado, especially J. Annear, G. Curtiss, J. Graves, J. Herron, J. McArdle, and J. Nelson. We give special thanks to L. Bonewell, T. Ingersoll, N. LaMantia-Olson, A. Piaggio, and C. Wilkey, and numerous volunteers of the Colorado Bats/Inactive Mines Project for assistance in the field. Finally, we thank B. Fowler, L. Lewis, K. Nickell, K. Philbrook, R. Robinson, and L. Wickstrom of the Bureau of Land Management, and J. Nuebert of the United States Forest Service, for support, funding, and involvement in bat conservation in the state. We thank J. Gore and J. Tigner for review and helpful suggestions on earlier drafts of the manuscript.

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Long-term Fidelity by Tree-roosting Bats to a Home Area

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Long-term studies of bats roosting in semi-permanent structures, such as buildings or caves, often reveal strong philopatry (e.g., Cope et al., 1991). Studies on tree-roosting bats, however, seldom last more than 1–2 years. Consequently, little information is available concerning long-term fidelity of these species to specific roosts or other aspects of their habitat.

From 1995 through 1998, a study of the roosting behavior and ecology of a maternity colony of Indiana bats (*Myotis sodalis*) was conducted near Norvell, Jackson Co., Michigan (Kurta et al., 2002). Members of this colony used a 600-m long fence line as a commuting corridor between various roosting and foraging areas (Fig. 1). The fence line contained a single row of mature trees, and the bats preferred to follow this narrow wooded path, rather than cross adjacent fields, even though this behavior increased their commuting distance by an average of 55% (Murray and Kurta, 2004). The bats would often follow this path multiple times in a single night, and some banded individuals were captured at the same location along the fence line in different years (Kurta and Murray, 2002). Indiana bats were netted at this fence line in 1995–1998 and in 2000, but no attempts were made to catch bats there in 1999 or in 2001–2003.

On 27 May 2004, we returned to this site and erected mist nets at the same location at which bats had been captured in previous years (Fig. 1). About 25 minutes after sunset, small bats, the size of Indiana bats, began flying along the fence line, from south to north, as they had in previous years. Five Indiana bats, all adult females, were captured within the next 30 minutes, and at least five similar-sized bats avoided the nets. *Myotis* of any species are uncommon in southern Lower Michigan (Kurta, 1982), and although none of the bats caught in 2004 was banded, it seems likely that they belonged to the same colony of Indiana bats that was studied extensively from 1995 to 1998. Thus, members of this maternity colony of Indiana bats probably used this commuting corridor for at least 9 years.

We placed a small radio-transmitter on one of the females and followed her to two day roosts in trees. The first roost tree was located ca. 2.1 km NNW of the capture site, in a patch of seasonally flooded deciduous forest; this site was near the boundary of a foraging area that originally was documented for the colony in 1998 (Murray and Kurta, 2004). The second tree was found ca. 0.93 km SE of the fence line in a forested wetland; this second site also was within a foraging area that had been discovered in 1998, and the new tree was located only ca. 150 m from the first roost tree of this colony, which was discovered 9 years earlier in 1995. Murray (1999; Murray and Kurta, 2004) speculated that Indiana bats find their roosts within foraging areas or along commuting corridors and that these sites should be less ephemeral than individual roost trees. Our observations support her hypothesis and suggest that colonies of Indiana bats probably show long-term fidelity to their home range. [After completing this manuscript, we learned that the radio-tracked female, which had been banded, was found hibernating on 27 January 2005, in a cave near Frenchburg, Kentucky (J. Kiser, pers. comm.), ca. 465 km from the fenceline].

Figure 1. Aerial photo of fence line used as a commuting corridor by Indiana bats in Jackson Co., Michigan. The netting location was to the right of the letter A, on the east side of the fence. Note the lack of other tree-lined corridors connecting wooded areas at the top and bottom of photo. Width of photo is ca. 2.5 km. North is at the top. Photo from U.S. Geological Survey.

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An Inexpensive, Mobile Antenna Tower for Radio-telemetry

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Radio-tracking highly mobile animals such as bats or passerines can be difficult because they often travel beyond the range of the small transmitters that are used. Increasing signal reception can greatly increase data collection and is often achieved by elevating the receiving antenna. Increased elevation can be accomplished by working from higher ground or by using devices such as towers to elevate the antenna. Many types of tower are available; however, most are costly, and many are somewhat immobile.

Herein, I describe a portable, inexpensive, and effective antenna tower that is constructed from many of the components that are used for erecting large mist-netting systems (e.g., Gardner et al., 1989). Although not as mobile as a vehicle-mounted system (Brinkman et al., 2002), this new 30-ft tower can be erected in less than 15 min, disassembled in less than 10 min, and transported easily in most field vehicles. The cost of the tower itself is under $100 U.S., and antenna cables and electronic adaptors are only an additional $50. The new tower provides substantial gains in reception compared with an antenna stationed at ground level. For example, when using a 5-element Yagi antenna at ground level and at the top of the 10-m tower, I found that maximum range of reception increased 75–80% for two transmitters (Model LB-2, Holohil Systems, Ltd., Ontario, Canada).

Components and Tools

No tools are necessary for assembly in the field, but some tools are required for initial construction. An electric drill, with 1/4- and 3/8-inch bits and 1 1/4-in hole-saw, is needed to prepare the poles and a wooden handle. Appropriately sized wrenches may be useful for tightening nuts and bolts, especially on the antenna bracket, and a metal file and sand paper are needed to smooth any rough or sharp edges.

The proposed hardware (Table 1) consists of sizes commonly available in the United States, but similar-sized metric pieces should be readily available in other countries. In any event, the only element that must be of a specific size is the axle bolt, which must match the inside diameter of the plastic screen-door roller. All other sizes are at the discretion of the builder.

Most components for the tower are carried by hardware stores, except the main sections of the tower, possibly the rollers, and the steel disks. The main body of the tower is constructed from telescoping, 10-ft-long poles that are sold by RadioShack (www.radioshack.com) as "antenna masts." The rollers/wheels are replacement pieces used in sliding screen or glass doors. They have a center ball-bearing race that reduces friction and allows them to spin freely.

The steel disks can be fashioned by a steel-works (welding) company and should be ca. 6 inches in diameter. The center hole should be just large enough to allow the antenna mast poles to slide through without excessive side-to-side movement; a 1 1/4-in (diameter) hole usually is sufficient, although some filing may be needed. Three 3/8-in holes for attachment of guy ropes should be drilled ca. 1/4 in from the edge of the disk, equidistant apart (Fig. 1a). Although holes are necessary only in one disk, drilling holes in both disks allows them to be interchangeable. After drilling, sharp edges on the steel disks should be removed, and the disks should be painted

Table 1. Quantity, dimensions, and cost of components need to construct the tower and antenna bracket

Number needed	Item	Dimensions, as sold in United States	Total approximate cost ($U.S.)
Tower			
3	interlocking antenna pole (RadioShack #15-863)	10-ft length	45.00
1	bucket	3 or 5 gal	5.00
2	bolts	2 1/2-in long, 1/4-in diameter	0.50
8	washers	1/4-in diameter	0.80
4	plastic screen door rollers/wheels (with center bearing)	1 1/2-in diameter	10.00
2	wing nuts	1/4-in diameter	1.00
2	steel disks	6-in diameter, 1/8-inch thick	10.00
3	rope	50-ft long, 1/8-in diameter	6.00
3	eyebolt snaps (dog-leash clips)	1-in diameter	6.00
3	tent stakes		1.50
1	wood (“1-by-2”)	18-in long	1.00
1	U-bolt	2-in long, 3/8-in diameter	2.00
2	wing nuts	3/8-inch diameter	1.00
1	Orange spray paint		3.00
1	Spray lubricant		3.00
Antenna and bracket			
1	Yagi antenna	5 element	150.00
1	RG-8 Cable (RadioShack #278-980)	50-ft long	40.00
	BNC adaptor; male PL-259 to female BNC (RadioShack #278-120)		11.00
1	electrical tape		1.00
1	L-bracket	2 1/2 in	1.00
4	bolts	1 1/2-in long, 1/4-inch diameter	1.00
4	nylon locking nuts	1/4-in diameter	1.00
2	wing nuts	1/4-in diameter	0.50

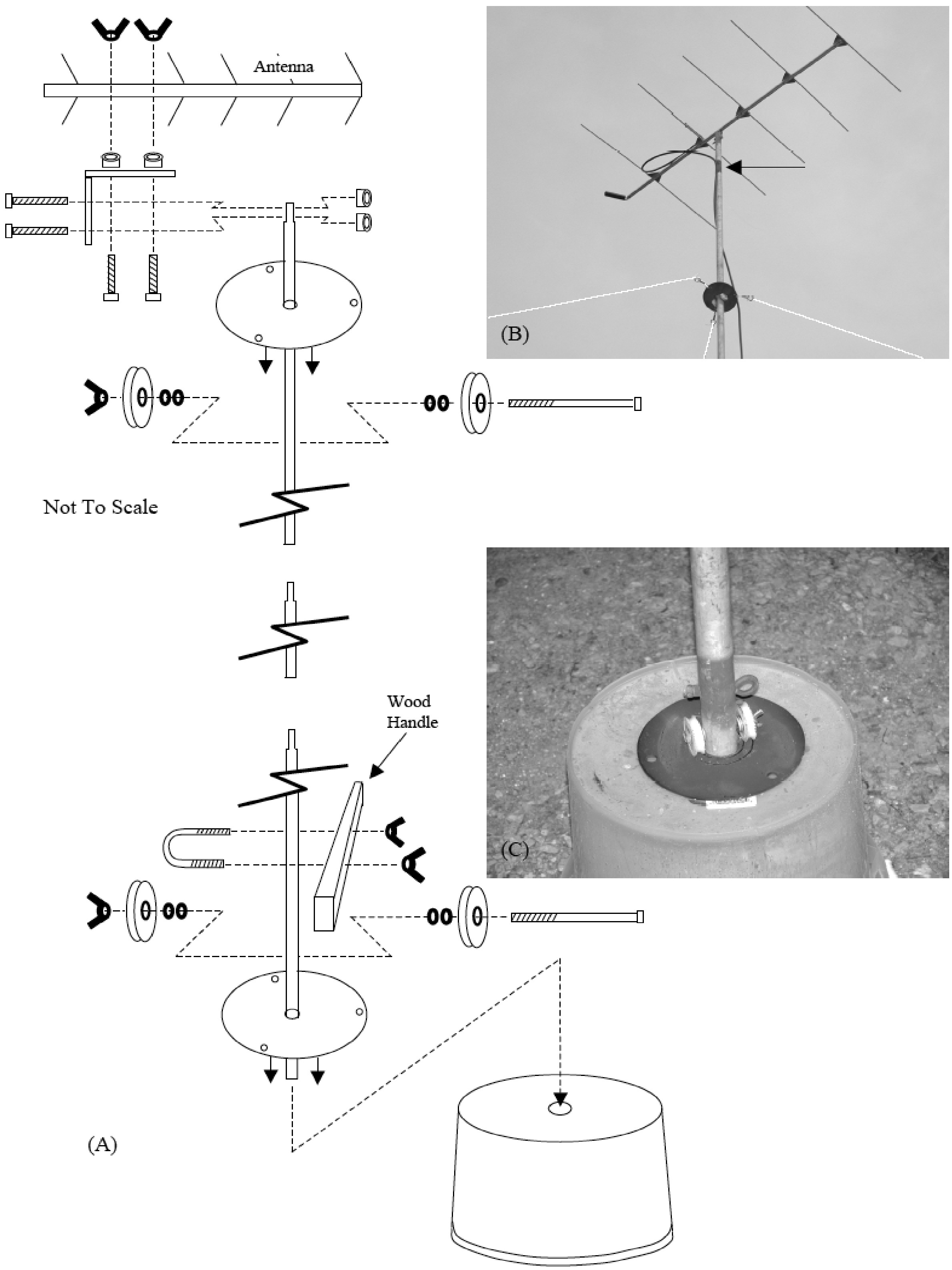

Figure 1. An inexpensive tower for radio-telemetry. A) Assembly schematic for a 30-ft tower. B) Photograph showing antenna, top support disk and axle, and use of electrical tape (arrow) to secure antenna cable to tower. C) Photograph showing the lower support disk and axle on the bucket.

to minimize corrosion. It also is recommended to paint all parts orange to increase visibility, in case they are dropped in the field, and to carry extra parts that are frequently lost (e.g., washers and wing nuts).

Use of RG-8 antenna cable between the antenna and the receiver is recommended because of its low signal-loss characteristics. However, suitable adaptors are needed to attach this long cable to the BNC connectors that are found on most antennas and receivers. Both antenna cable and adaptors can be purchased from RadioShack or a similar electronics supplier.

Construction

Drill two 1/4-in holes in the top of the pole to attach the L-bracket using two 1 1/2-in bolts and two nylon locking nuts (Fig. 1a). Mount the other two 1 1/2-in bolts in the top of the L-bracket with nylon locking nuts. Point the thread upward so that the antenna may be mounted on top of these bolts and secured with the 1/4-in wing nuts (Fig. 1a). Drill two 1/4-in holes in the antenna to match the bolts on the bracket.

Drill a 1/4-in hole through the top pole, about halfway down, and another through the bottom pole, no higher than the height of the bucket. The latter hole must be positioned so that the wheels of the axle will rest on top of the bucket without the pole touching the ground (generally 8–10 in for a 3-gal bucket; Fig. 1c). Drill a 1 1/4-in hole in the center of the bottom of the bucket so that the hole is slightly larger than the diameter of the antenna pole. A 3-gal bucket is better than a 5-gal pail, because of the lower center of gravity, but a 5-gal bucket can be used.

Cut an 18-in-long piece of wood from a "1-by-2" or similar-sized piece of scrap. This wood will be used for a handle to assist in turning the tower. Drill two 3/8-in holes in the center of the wood for the U-bolt (Fig. 1a). Sand to avoid splinters.

As mentioned, a rope will be attached to each of the three holes in the top steel disk to act as guy ropes once the pole is erected. Although knots can be tied and untied each time the pole is used, it often is quicker if each rope has one end permanently connected to an eye-bolt (dog-leash) snap.

Assembly in the Field

Two or more people are needed to assemble and raise the tower, but the process takes less than 15 min. Slide the metal disk onto the top pole above the 1/4-in hole. To assemble the top axle-shaft, place one screen-door wheel on the 2 1/2-in-long bolt followed by two washers. Insert the bolt through the hole in the top pole. Place two more washers and the second screen-door wheel on the bolt, and secure with a wing nut (Fig. 1a). Wheels should spin freely, so spray with lubricant if needed.

For a 20-ft tower, connect the top and bottom poles, but for a 30-ft tower, add a section between the top and bottom poles (Fig. 1a). Clip a rope to each of the three holes in the upper disk, and unwind the rope to the bottom of the assembled pole. Now assemble the axle shaft for the bottom pole as you did for the top pole. Note, however, that the second metal disk is positioned below the axle to distribute the weight of the tower across the bucket.

Attach the antenna to its bracket, but be careful not to damage the antenna with the weight of the rig while it is resting on the ground. Attach the antenna cable to the antenna, and unwind the cable to the base of the pole. Use the electrical tape to attach the cable to the pole midway between the antenna and the upper disk to reduce stress on the connector (Fig. 1b).

Raise the tower to vertical, with the bottom pole resting on the ground, but do not use the bucket yet. Be sure that ropes and cables do not snag on vegetation or other obstructions. While one person keeps the pole erect, another person should extend the guy ropes and tie them to a fence, tree, or other structure. Tent stakes can be used in areas where no solid structures are available.

After ropes are tied, position the bucket (bottom up) next to the pole, with the metal disk on top. Carefully raise the pole straight up, and slide the bucket under the pole; now lower the pole through the disk and bucket (Fig. 1c) so that the wheels sit on the metal disk. Adjust the base to ensure that the tower is vertical, and adjust tension on the guy ropes to secure the pole. Be sure to attach the free end of the cable to the receiver.

For easier turning of the tower, attach the wooden handle to the bottom pole at a comfortable height using the U-bolt (Fig. 1a). Although the tower can be turned in either direction, avoid turning past 360^{o} because resulting tension on the cable will stress the antenna and result in damage. After disassembly, the bucket can be used to carry all parts, but put small pieces (e.g., washers, bolts, and nuts) in a small bag to prevent them from falling through the hole in the bucket.

This tower was designed for determining approximate directions to research animals. Recording precise bearings may be facilitated with the addition of a pointer mounted to the bottom of the pole and a compass rosette added to either the bucket or the lower disk. However, calibration would be needed each time the tower was erected. Alternatively an electronic compass could be used (Brinkman et al., 2002).

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RECENT LITERATURE

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The 70th Birthday of Professor Jirí Gaisler, D.Sc.

Professor Jirí Gaisler, a prominent Czech zoologist and university teacher of zoology, was born in Prague, on 3 July 1934. In 1957, he graduated in Biology at the Faculty of Science of Charles University in Prague, and from 1957 to 1969, he worked as a research assistant and later as a researcher at the Institute of Vertebrate Biology, Academy of Sciences of the Czech Republic. In 1969, he joined the Department of Animal and Human Biology of the Faculty of Science, University of Jan Evangelista Purkyne at Brno (now called the Department of Zoology and Ecology of the Faculty of Science, Masaryk University), where he has been working with short breaks up to the present time. He became an Associate Professor of Zoology in 1979, and in 1991, after the Velvet Revolution, he was appointed full Professor of Zoology. Prof. Gaisler also served as Head of the Department of Zoology and Ecology (1990–1996) and Vice Dean of the Faculty of Science (1995–1999). Today, at the age of 70, he continues working at the Department of Zoology and Ecology as Professor Emeritus.

Throughout his career, Prof. Gaisler has been interested mainly in the ecology of bats, and together with Prof. Vladimír Hanák, he is considered the founder of modern Czech and Slovak chiropterology. His doctoral thesis was on the ecology of *Rhinolophus hipposideros*, and the results of this work were published in three key papers (1963), which are still being cited. A comprehensive list of his publications was published on the occasion of his 60th birthday (Folia Zoologica, 43:292–296), and it included 128 original scientific papers. Within the last 10 years (1994–2004), the list has increased by another 32 scientific contributions and five chapters in monographs. Some of his most important recent works are three chapters (on *R. ferrumequinum*, *R. euryale* and *R. mehelyi*) in *Handbuch der Säugetiere Europas*, and his co-authorship of the extensive reports "Bats of the Palearctic Region: a Taxonomic and Biogeographic Review" and "Results of Bat Banding in the Czech and Slovak Republics, 1948–2000."

In addition to scientific papers, Prof. Gaisler has produced a number of books. Besides the lecture notes titled *Introduction to Vertebrate Zoology* (first edition in 1973) and *Introduction to Ethology* (1989), Prof. Gaisler published a valuable textbook, *Vertebrate Zoology* (1983), and compiled the *Atlas of Mammals of the Czech and Slovak Republics* (2002). He also co-authored many other books, such as *Field Course in Zoology* (1981), *Primatology for Anthropologists* (2000), and *Phylogenesis, System and Biology of Living Organisms* (1992, 2001). Furthermore, he edited a number of proceedings, and he acted as co-editor of a major species inventory, *Vertebrates of the Pálava Biosphere Reserve* (2002). He remains involved and is currently preparing a new textbook of vertebrate biology with Prof. Zima.

He was a co-founder and first chairman of the Czech Bat Conservation Trust, and today, he is the honorary president. He also serves as a member of the Scientific Board of the Institute of Vertebrate Biology; the Czech Zoological Society, the National Committee of the International Union of Biological Sciences, the American Society of Mammalogists (lifetime member), the Chiroptera Specialist Group of the IUCN Species Survival Commission, and the Scientific Advisory Board of Bat Conservation International. In addition, he is a current member of the editorial boards of the scientific journals *Acta Theriologica*, *Lynx*, and *Folia Zoologica*.

For his achievements in biology, he was awarded the G. J. Mendel Medal of Honor of the Academy of Sciences of the Czech Republic in 1995. In 1999, he received the Prize of the Rector of Masaryk University in Brno for his book *Mammals*, which has been published in five languages.

Professor Gaisler is a very learned person with eclectic interests. He has excellent comprehension of various scientific fields, is well read, and continues to have a very good memory. He is also fluent in Czech, Slovak, English, French, German, and Russian, and has a fair understanding of Polish. Considering his age, he is physically fit, and the same is true for his senses. His excellent hearing gives him not only a predisposition for the identification of birdcalls but also for a very sensitive perception of music. He loves jazz and likes to play piano. Being of high vitality, he is not content with his many achievements but continues to be in contact with modern science and is always eager for new knowledge. This is one of the many reasons that he is highly respected by his students, colleagues, and friends.

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In Memory: Eugene H. Studier

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During my freshman year in college, I often heard from upperclassmen that I should, if possible, avoid several classes, especially cellular biology and mammalian physiology. I ignored those comments and enrolled in cell biology my sophomore year. I quickly learned though why I was told to avoid cell biology. I still remember this old guy standing in front of the class and drawing the molecular structures of dozens of polysaccharides, phospholipids, nucleic acids, and proteins and all within the first few weeks. I remember thinking, "what did I get myself into?" Although I received only a modest grade in cell biology, the laboratory instructor apparently saw something in my efforts and asked me to assist the following semester. Accepting that offer meant that I would actually have to meet and work with that old man who taught cell biology. I finally was introduced to "Doc" Gene Studier, and from that day forward, he was ever present in my personal and academic life.

I enrolled in several of Doc's classes: Mammalian Physiology, Comparative Physiology, and my favorite, Research Methods: a Study of Mammoth Cave Biota. The course on cave biota was team taught by five faculty members and was limited to 10 students. Each student was required to design an experiment that would be implemented at Mammoth Cave National Park, Kentucky. Doc and I designed an experiment to determine if white-footed mice (*Peromyscus leucopus*) would concentrate foraging efforts near entrances to caves that had nightly emergences of cave crickets (*Hadenoecus subterraneus*). We later published the results of our study, as did five other students in the class.

Doc was instrumental in nurturing hundreds of students to pursue advanced degrees in graduate school or one of the professional schools. Although I went on to graduate school to study with Al Kurta at Eastern Michigan University, I kept in constant touch with Doc, and after finishing, I returned to the University of Michigan—Flint and began my own career as an academic. I can honestly say that I have lost a best friend and father figure. I learned much from Doc, at first in the classroom, but also later during our daily conversations, games of cribbage or gin, and the many rounds of pool and fishing trips.

Gene graduated from Dubuque Senior High School, in Dubuque, Iowa, in 1958. He attended the University of Dubuque and graduated with baccalaureate degrees in Biology and Chemistry (1958–62) before receiving his Doctorate of Zoology from the University of Arizona, just 3 years later, in 1965. He became an Assistant Professor at New Mexico Highlands University, in Las Vegas, New Mexico, in 1965, receiving tenure in 1969, and continuing there as an Associate Professor until 1972. During his brief stay at New Mexico Highlands, Gene directed the thesis work of 17 graduate students.

He joined the faculty of the University of Michigan—Flint in 1972 as Associate Professor of Biology and was promoted to Professor in 1974. Gene's tenure at the University of Michigan—Flint spanned 32 years, until his unexpected death in 2004, and during that time, he was involved with all aspects of the Biology Department. He was instrumental in developing the biology curriculum during a period of major departmental growth, and he served as Chair of the Biology Department from 1978 to 1985 and from 1994 to 2000. He was the impetus in developing a Master of Science in Biology Program at the University of Michigan—Flint, and acted as its Director and major motivating force after its inception in 2000. Gene also contributed his talents to 14 different committees for the College of Arts and Sciences and the University. In recognition of his excellence in teaching, research and service, he was honored with the David M. French Distinguished Professor Award, the highest faculty honor given by the University of Michigan—Flint.

Gene enjoyed the study of bats and was widely published in the field. During 42 years of service to academics, he published more than 80 articles in refereed journals, as well as several book chapters, and he presented at numerous academic meetings. His publication record is extraordinary, especially in light of the absence of a graduate program at the University of Michigan—Flint for most of his career. Even more remarkable is that many of his published works were co-authored by undergraduates. Even on his last sabbatical, Gene continued to involve undergraduates, spending 2 months in Papau New Guinea and Australia studying bats and tree kangaroos (*Dendrolagus*) with three of our undergraduate students and me. Each of those undergraduates reveled at the opportunity to work in Papau New Guinea, and they eventually began their own research in Africa and Asia.

Doc often said, "What better life could you ask for, when you are able to go to work excited and be excited to return home." Gene loved spending time in his garden, enjoyed fishing, and was an avid golfer and racquetball player. Surviving are his wife, Ann; children, David of Michigan; Robb and Carrie of New York; and Hollie of New Mexico; and six grandchildren, Chase, Sydney, Corey, Lindsey, Jason, and Mathia. He was preceded in death by his parents, Herbert and Jeanetta Studier and his sister, Delores Acheson. He will be missed by his current and former students and his colleagues and friends from the University and around the world.

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FUTURE MEETINGS and EVENTS

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/

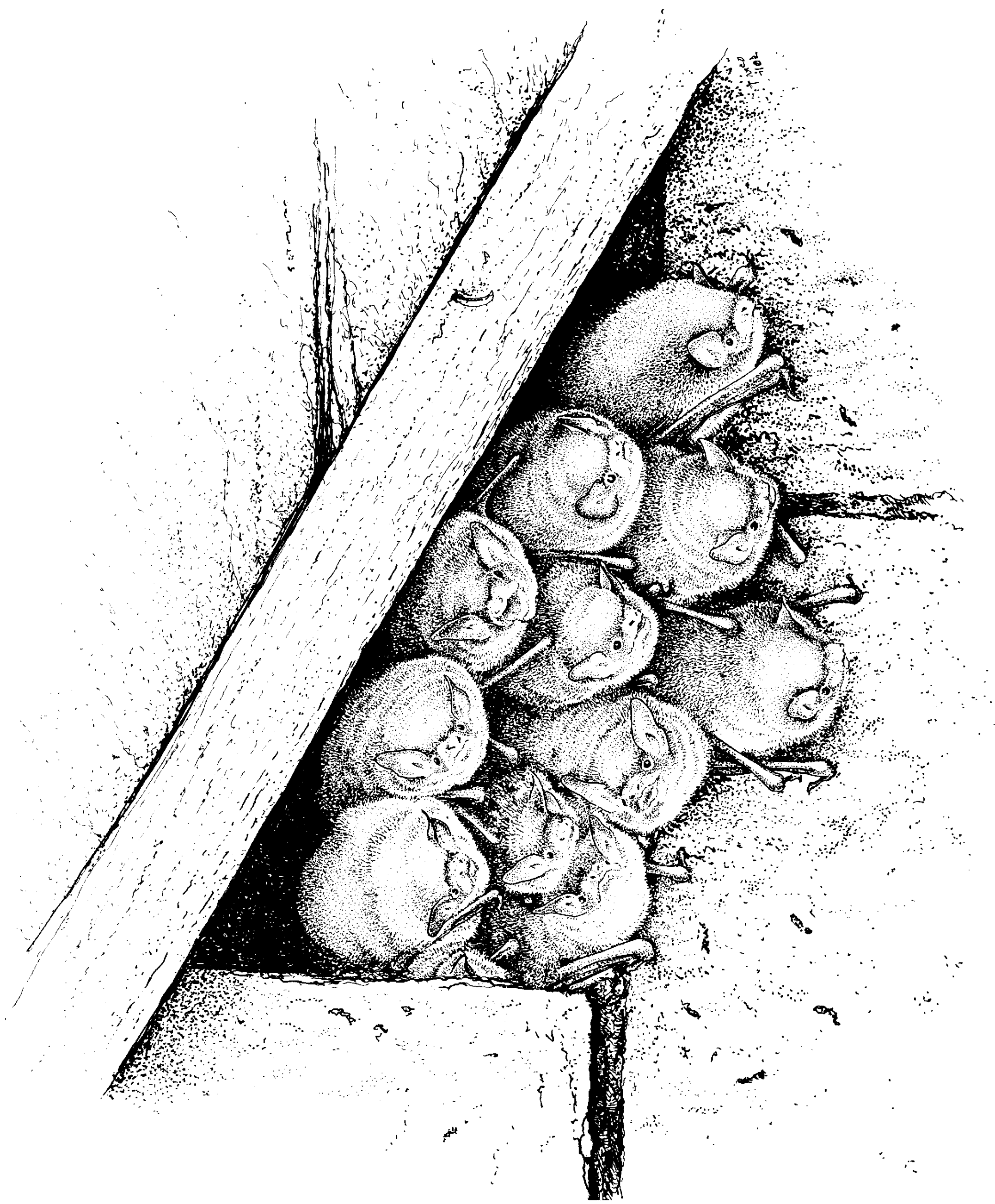
August 21 - 26, 2005
The 10th European Bat Research Symposium will meet in Galway, Ireland. All sessions will be held on the National University of Ireland campus, which is located near the center of Galway city. The symposium convener is Jimmy Dunne, Department of Zoology, National University of Ireland, Galway. Details are available on the symposium websites:http://www.ebrs10.com/orhttp://www.nuigalway.ie/

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: http://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. The local host is Winston Lancaster. All meeting activities will be held at the Holiday Inn Sacramento Capitol Plaza, where a block of guestrooms has been reserved for NASBR participants. Additional information will be posted on the society's web site http://www.nasbr.org/in early June 2005, or you may 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. As additional information becomes available, it will be posted on the society's web site http://www.nasbr.org/ or you may contact Margaret Griffiths: mgriff@illinoisalumni.org

BAT RESEARCH NEWS



VOLUME 46: No. 2 SUMMER 2005

BAT RESEARCH NEWS

VOLUME 46: No. 2 **Summer 2005**

Table of Contents

Front Cover

The drawing of *Myotis daubentoni* on the front cover was provided by Tom McOwat of Llandysul, Wales. (Copyright 2005 by the artist.) Thank you, Tom, for sharing your work with us.

A Review of Bat Mortality at Wind-energy Developments in the United States

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As of 2004, commercial wind-energy farms have been constructed in 32 states, and total wind-power capacity in the United States is 6,740 megawatts, which is enough to supply electricity for over 1.6 million homes (American Wind Energy Association, 2005). Although development of sources of renewable energy generally is considered environmentally friendly, wind-power development has been associated with the deaths of birds (Erickson et al., 2001) and bats (Johnson, 2004) that collide with turbines. In several cases, the number of bat fatalities at wind farms has exceeded the number of avian fatalities, and the recent death of 475 bats at a 44-turbine wind plant in West Virginia has created considerable interest in this issue among conservation groups, state and federal wildlife agencies, and the wind-energy industry (Tuttle, 2004; Williams, 2003). The purpose of this review is to synthesize the available data on bat mortality at wind-energy facilities and to provide background information for researchers who may be developing study plans to address impacts at existing or proposed wind-energy sites.

Mortality of bats from collisions is not unique to wind farms. Bats have died after colliding with other tall, man-made structures, including lighthouses (Saunders, 1930), communication towers (e.g., Crawford and Baker, 1981; Van Gelder, 1956; Zinn and Baker, 1979), and buildings (Terres, 1956; Timm, 1989). Mortality of bats at wind farms was first documented in Australia, where 22 white-striped mastiff bats (*Tadarida australis*) were found at turbines over a 4-year period (Hall and Richards, 1972), and ultimately, collisions were documented in Canada (unpublished data), Germany (Bach, 2001), Spain (unpublished data), and Sweden (Ahlen, 2002). In the United States, such mortality was first reported in Minnesota (Johnson et al., 2003; Osborn et al., 1996), and fatalities now have been documented at wind farms in 10 other states (Johnson, 2004).

Eleven of the 45 species of bats in North America were included among the fatalities at wind farms, although none was classified as threatened or endangered by the federal government (Johnson, 2004). Most (83.2%) fatalities involved migratory tree bats. Of 1,440 bats identified to species, hoary bats (*Lasiurus cinereus*) comprised 45.5%, eastern red bats (*L. borealis*), 26.3%, and silver-haired bats (*Lasionycteris noctivagans*), 11.4% (Table 1). The remaining fatalities were primarily eastern pipistrelles (*Pipistrellus subflavus*, 8.5%), little brown bats (*Myotis lucifugus*, 5.9%), and big brown bats (*Eptesicus fuscus*, 1.9%). In addition, six northern long-eared bats (*Myotis septentrionalis*) and single specimens of the western red bat (*Lasiurus blossevillii*), Brazilian free-tailed bat (*Tadarida brasiliensis*), long-eared myotis (*Myotis evotis*), and Seminole bat (*Lasiurus seminolus*) were found at U.S. wind farms.

Regional differences occurred in species composition of the fatalities (Johnson, 2004). Hoary and eastern red bats comprised most fatalities in the Upper Midwest, whereas eastern red, eastern pipistrelle, and hoary bats were most common in the East. Victims in the Pacific Northwest were composed of near-equal numbers of silver-haired and hoary bats, whereas most fatalities in the Rocky Mountain West were hoary bats (Table 1).

The approximate date of the collision was reported for 1,628 fatalities of bats in the United States. About 90% of fatalities occurred from mid-July through late September, with over 50% occurring in August (Fig. 1). Although this time corresponded with fall migration and dispersal

Table 1. Regional composition of fatalities from collisions at wind farms in the United States

Species	Number (%) of fatalities by region[a]				Total
	Pacific Northwest	Rocky Mountains	Upper Midwest	East	
Hoary bat	91 (48.7)	155 (91.2)	309 (62.7)	100 (16.9)	655 (45.5)
Eastern red bat			106 (21.5)	273 (46.3)	379 (26.3)
Silver-haired bat	92 (49.2)	7 (4.1)	35 (7.1)	30 (5.1)	164 (11.4)
Eastern pipistrelle			7 (1.4)	116 (19.7)	123 (8.5)
Little brown bat	2 (1.1)	6 (3.5)	17 (3.4)	60 (10.2)	85 (5.9)
Big brown bat	2 (1.1)	2 (1.2)	19 (3.9)	4 (0.7)	27 (1.9)
Other[b]				7 (1.2)	7 (0.5)
Total[c]	187 (13.0)	170 (11.8)	493 (34.2)	590 (41.0)	1,440 (100)

[a] Pacific Northwest = four wind-energy facilities in eastern Oregon and Washington; Rocky Mountains = two facilities (one each in Wyoming and Colorado); Upper Midwest = three facilities (one each in Minnesota, Wisconsin, and Iowa); and East = two facilities (one each in West Virginia and Tennessee).
[b] Includes six northern long-eared myotis (*Myotis septentrionalis*) and one Seminole bat (*Lasiurus seminolus*).
[c] Percentage indicated is the percent of the grand total of 1,440 bats.

from summer breeding areas, it is not known whether the bats that died actually were migrating or conducting other activities during this period.

Mortality during the breeding season was low, with only 66 fatalities (4.1%) between May 15 and July 15. At several wind farms, low mortality occurred during the breeding season even though large populations of bats were present in the area (Fiedler, 2004; Gruver, 2002; Howe et al., 2002; Johnson et al., 2004; Schmidt et al., 2003). However, most of these wind farms were in open habitats, and perhaps breeding bats would be more prone to collisions at wind farms that were constructed in typical foraging habitats, such as forested areas.

Collisions apparently were very low during spring migration, with only nine fatalities from mid–April to mid–May, although fewer studies were conducted during spring. However, spring migrants also rarely were killed at other structures; for example, 48 eastern red bats were collected at a building in Chicago in fall, but only two were found in spring (Timm, 1989). Fewer collisions in fall may have resulted from tree bats following different migratory routes in spring and fall (Cryan, 2003), or perhaps autumn migration occurred in waves, with spring migration more scattered, as reported for hoary bats (Zinn and Baker, 1979).

Eleven studies were conducted in the United States to estimate fatality rates of bats at wind farms, including four in the Pacific Northwest (Oregon and Washington), four in the Upper Midwest (two in Minnesota, Wisconsin, and Iowa), one in the Rocky Mountains (Wyoming), and two in the East (West Virginia and Tennessee—Johnson, in press). Estimated annual fatality rates for these regions, after adjustment for bats not detected by searchers or removed by scavengers, were 1.2 bats/turbine in the Pacific Northwest and Rocky Mountains, 1.7 bats/turbine in the Upper Midwest, and 46.3 bats/turbine in the East. Number of estimated fatalities for individual projects ranged from19 bats/year at a 16-turbine wind farm in Oregon to 1,800 bats/year at a 44-turbine facility in West Virginia. All wind farms studied in the West and Midwest were located in open habitats, such as agricultural fields, grasslands, and shrub-steppe. In contrast, both facilities in the East were on forested ridge tops in the Appalachian Mountains. These studies suggested that mortality rates were highest in forested environments (such as those

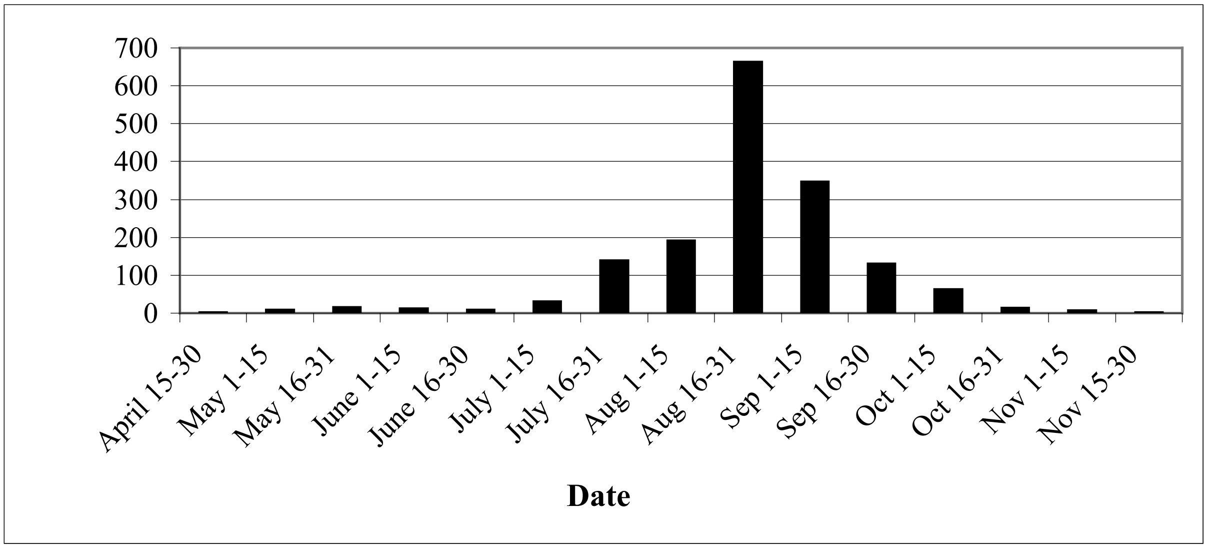

Figure 1. Seasonal distribution of fatalities from collisions of bats at wind farms in the United States.

in the East), moderate in open areas close to forests (typical of Midwestern sites), and lowest in open areas (Rocky Mountains and Pacific Northwest). Differences in fatality rates may have been related to differences in geographic region, habitat, topography, population sizes of bats, weather, or unknown factors. Forested ridge tops also may be used by bats as migration corridors, whereas it is unlikely that migrating bats would be concentrated in more open habitats.

Only a small fraction of bats that traverse wind farms actually collided with turbines. For example, at Buffalo Ridge, Minnesota, where mortality over a 2-year period was 1,213 bats, echolocation monitoring indicated a minimum of 96,102 bat passes near turbines (Johnson et al., 2004). The cause of collisions with wind turbines or other man-made structures is not well understood. Inclement weather did not appear strongly correlated with mortality of bats. About half the collisions at Buffalo Ridge, Minnesota, occurred in clear weather (Johnson et al., 2004), whereas fatalities occurred during both clear and inclement weather at Buffalo Mountain, Tennessee (Nicholson, 2003). Turbines somehow may have attracted bats, or perhaps bats could not detect moving turbine blades. The potential role of these factors was supported by the lack of fatalities at stationary meteorological towers that were constructed at wind farms; however, bats in a laboratory setting avoided colliding with moving objects more successfully than stationary ones (Jen and McCarty, 1978). Warning lights for airplanes that were placed on turbines apparently did not increase fatalities. For example, every other turbine was lighted with non-pulsating red lights at a 138-turbine facility in Minnesota, but there was no difference in mortality or echolocation activity at lighted and unlighted turbines (Johnson et al., 2004). Other studies conducted in Washington and Oregon also failed to find differences in fatality rates among lit and unlit turbines (unpublished data).

Despite the number of studies conducted to date (see Johnson and Arnett, 2004), there is still much to be learned. Additional information is required to develop methods to assess risk to bats before development of wind-energy facilities, determine effect of mortality from collisions on population dynamics, determine what factors (e.g., weather and turbine operation) are associated with the collisions, monitor behavior of bats near turbines, and, most importantly, develop methods to eliminate or reduce mortality of bats from collisions. To address these gaps in our knowledge, the Bats and Wind Energy Cooperative was formed in 2003 by Bat Conservation International, the U.S. Fish and Wildlife Service, the American Wind Energy Association, and the National Renewable Energy Laboratory of the U.S. Department of Energy (Arnett, in press). Hopefully, research initiated by the cooperative and other groups will develop solutions to minimize or prevent mortality of bats at wind-energy facilities.

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Collisions with Aircraft and Use of Culverts under Runways by Bats at U.S. Naval Air Station Meridian, Meridian, Mississippi

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Introduction

Collisions of bats with aircraft occur in many regions of the United States. Since 1997, for example, remains from more than 126 bats that collided with military aircraft ("bat strikes") have been processed by the U.S. Geological Survey, Biological Survey Unit, at the National Museum of Natural History, Washington, D.C. (Peurach, 2004). In addition, Eugene LeBoeuf (pers. comm.), of the U.S. Air Force (USAF) Bird Aircraft Strike Hazard (BASH) Team, stated that the location of cave- or bridge-dwelling species of bats, especially large populations of Brazilian free-tailed bats (*Tadarida brasiliensis*), often were considered when the Air Force planned flight exercises; he noted, however, that serious bat incidents were rare in the United States. Similarly, Presuto and Windler (2005) reported that even though 52 bats struck planes of the USAF in 2004, all were considered minor mishaps. Nevertheless, Dove and Peurach (2001) documented the first damaging bat strike to a USAF military aircraft in this country. On 18 November 1999, a USAF T-37-B aircraft sustained a strike, requiring ca. $10,000 in repairs to the air-conditioning intake, during a flight from Randolph Air Force Base near San Antonio, Texas; hair samples from the dead animal best matched those of a Brazilian free-tailed bat (Dove and Peurach, 2001). Brazilian free-tailed bats and red bats (*Lasiurus* spp.) apparently were the species that most commonly collided with planes of the USAF (Peurach, 2004).

Matthew Klope (U.S. Navy, BASH Program Manager, Port Hueneme, California, pers. comm.) provided records of wildlife strikes occurring since 1982 at installations of the U.S. Navy. These collisions involved a silver-haired bat (*Lasionycteris noctivagans*), a hoary bat (*Lasiurus cinereus*), and an unidentified species struck in September 2002 at Whidbey Island, Washington; unidentified species of bats also were struck at Naval Air Station (NAS) Corpus Christi, Texas, in February 2002 and August 2004; NAS Point Mugu, California, in March and September 2004; and NAS Jacksonville, Florida, in June 2004. None of these strikes was considered damaging to the aircraft.

The U.S. Naval Air Station Meridian (NASM) is a training facility located near the city of Meridian, in Lauderdale and Kemper counties, in east-central Mississippi. As part of its pilot-training program, T-2 Buckeye and T-45 Goshawk jets fly year-round, nighttime, take-off-and-landing exercises. Records of collisions on the base between aircraft and large wildlife, especially white-tailed deer (*Odocoileus virginianus*), have been maintained since the early 1980s, and in 2000, personnel at the installation also began recording collisions with smaller animals, including bats. The first bat strikes were logged in fall 2000, and because of these collisions, NASM became concerned about the potential hazard posed by bats that roosted in culverts beneath the installation's runways. This report summarizes our attempt to examine specimens struck by aircraft from NASM during 2000–2004 and to inspect culverts under runways at NASM to determine use by bats.

Bat Strikes at Naval Air Station Meridian

Five strikes were reported on NASM in 2000. Examination of body remnants collected during post-flight inspections revealed that the bats that collided on 29 August, 5 September, and 14 September 2000 were eastern red bats (*Lasiurus borealis*). No material was saved from a bat struck on 26 September, and it was categorized as unknown. Although little was left of a bat hit on 4 October, wing measurements, shape of the tragus, and coloration of the fur most closely fit that of an evening bat (*Nycticeius humeralis*). Three bat strikes were reported in 2001 (7 July, 1 August, and 7 August), and all involved eastern red bats. Six bats were struck by aircraft in 2002; eastern red bats were reported on 19 April, 18 June, and 7 August, and eastern pipistrelles (*Pipistrellus subflavus*) were hit on 9 April, 16 July, and 17 July. No strikes were reported in 2003, which may reflect a breakdown in reporting vigilance rather than total absence of bat strikes. Collisions in 2004 included an unidentified bat on 9 June and an eastern red bat on 22 September.

Inspections of Culverts

Culverts occur under both the north and south runways at NASM for passage of two major streams, Ponta Creek and Big Reed Creek. Culvert complexes at the south runway include three adjoining tunnels, each ca. 7-m high, 5-m wide, and 180-m long. Culverts under the north runway consist of four adjacent units, each of which is ca. 3-m tall, 3-m wide, and 250-m long. Habitat adjacent to the runways consists primarily of narrow strips of riparian hardwoods surrounded by loblolly pine (*Pinus taeda*) and mixed woodlands.

We first inspected the culverts on 11 October 2000. Hand nets were used to collect samples to confirm species identification and determine sex, age, and reproductive condition, and all bats were released following examination. On that date, ca. 50 southeastern bats (*Myotis austroriparius*) were observed in culverts under the south runway, and 15 eastern pipistrelles, 10 southeastern bats, and 5 Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) were counted under the north runway. These species roost in tunnel-like structures in other areas of the Southeast (Keeley and Tuttle, 1999; Mirowsky et al., 2004; Sandel et al., 2001; Walker et al., 1996), so their use of the culverts was not considered unusual. Southeastern bats sampled with hand nets on 11 October included one adult female and six adult males, two of which had distended testes.

We also visited the culverts in 2001 and 2002. A total of 730 southeastern bats were tallied under the south runway on 21 August 2001, but no other species were noted. Eighteen southeastern bats and four eastern pipistrelles were counted beneath the north runway on that day. On 13 June 2002, counts included 233 southeastern bats, one eastern pipistrelle, and one big-brown bat (*Eptesicus fuscus*) at the south runway, and five southeastern bats and one eastern pipistrelle at the north runway. Ten southeastern bats were netted in the culverts, and these included two adult males, six lactating or post-lactating females, and two immature females.

Discussion

Sixteen bat strikes were reported from 2000 to 2004 on NASM; these included ten eastern red bats, three eastern pipistrelles, one evening bat, and two bats of unknown species. Most strikes occurred during late summer and fall, except for 2002, when several strikes were recorded in April and June. Both eastern red bats and evening bats are migratory species (Boyles et al., 2003; Cryan, 2003), and the predominance of strikes during fall may indicate that these bats were migrating. Number of collisions that are recorded probably is an underestimate of the total number of bats that are struck by aircraft at NASM, because animal remains from strikes often go unreported and inspection crews are not always diligent or consistent in their reporting procedures.

The extensive culverts, especially at the south runway, provided roosting habitat for a large population of southeastern bats. A sample of bats using the culverts on 11 October 2000 and 13 June 2002 indicated that culverts served as maternity roosts, and the tunnels were used by both males and females throughout much of the year. Although Rafinesque's big-eared bats also roosted in the culverts, neither Rafinesque's big-eared bat nor the southeastern bat, both of which are protected species in Mississippi (Mississippi Natural Heritage Program, 2001), have been involved in bat strikes at the installation. Hence, these sensitive species did not appear to be hazards to naval aircraft.

Finally similarities were noted in species composition and timing of bat collisions with aircraft and bat collisions with large towers and wind turbines (Johnson, 2005). For both types of collisions, lasiurines, especially eastern and western red bats (*L. blossevillii*) and/or hoary bats, form a large proportion of the victims in North America. In addition, most collisions of bats with aircraft, as well as those with terrestrial structures, take place during autumn migration. Additional research is needed to identify ways to minimize bat collisions with both stationary and moving objects.

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Albinism in the Indiana Bat, *Myotis sodalis*

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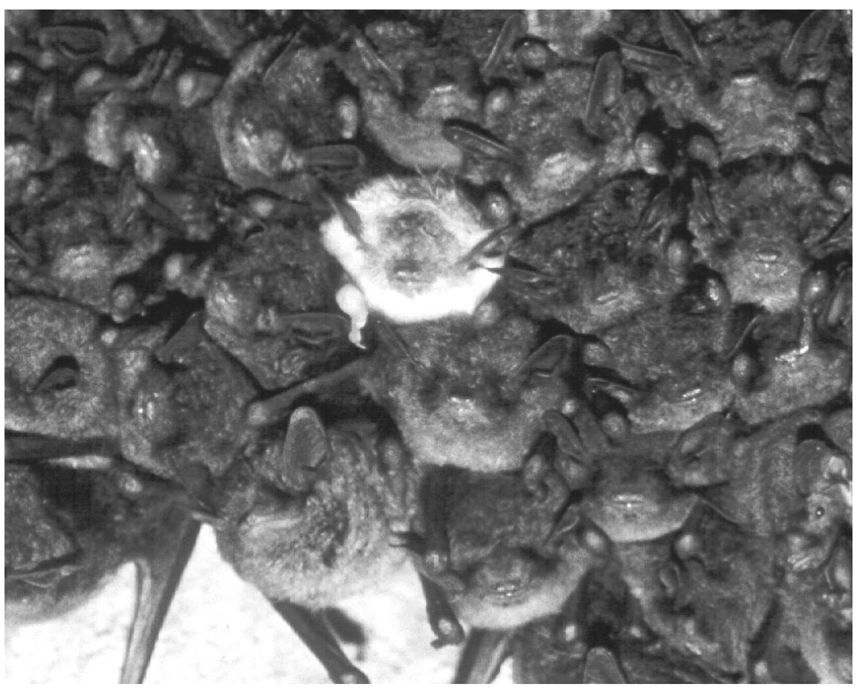
Although complete albinism in bats is rare (reviewed by Uieda, 2000) and there are few published incidences of partial albinism (i.e., leucistic individuals; e.g., Walley, 1971), the occurrence of white and leucistic Indiana myotis (*Myotis sodalis*) is a reoccurring phenomenon. Metzger (1956) found an adult male *M. sodalis* in Bat Cave, Kentucky, with hair that was white, except the extreme tips of guard hairs, which were tinged with brown. Barbour and Davis (1969) reported that *M. sodalis* sometimes had a conspicuous white patch on the dorsum or venter, varying in size from a small patch to an area covering a third of the furred surface. They also said that the frequency of such markings varied from one in three hundred to one in several thousand individuals. Mumford and Whitaker (1982) reported three *M. sodalis* with white spots in Wyandotte Cave, Indiana, and during biennial censuses of bats hibernating in Indiana (Brack et al., 2003), we found a number of other examples that we summarize in this report.

We first saw a white *M. sodalis*, an apparent albino, in Ray's Cave, in central Indiana, during censuses in 1985, 1987, and 1989 (Brack and Johnson, 1990). A white bat, presumably this same individual, was found in Ray's Cave in 1991, when seven additional bats with varying amounts of white pelage were discovered. These included an individual with a distinct white band across the scapular area (Fig. 1a), normal pelage with a smudge of white ca. 1–2 cm in diameter in the scapular area, a white bat with a similar smudge of gray, and other variations in between (Fig. 1b). In 1993, only a single bat with white markings (a white belly) was found. Similarly, in 1995, a single leucistic bat was seen, and it did not appear to be any of the individuals that we had previously observed. Although no color abnormalities were noticed in 1997, a bat with a white spot on its face was noted in 1999. In 2001, a bat with blond fur (intermediate in color between white and gray with a yellowish hue) and a partly white bat were found. In 2003, no color abnormalities were seen in this cave, but in 2005, an individual with a light-colored dorsal patch was observed.

During our censuses from 1985 to 2005, essentially all *M. sodalis* hibernating in Indiana were observed, yet we found only two white bats in other caves. In 2005, a white bat was found in Coon Cave, ca. 16 km NE of Ray's Cave, and a blond bat with a white face was found in Jug Hole Cave, ca. 100 km S of Ray's Cave. Coincidently, also in 2005, J. Kath (pers. comm.) found a totally white *M. sodalis* in Illinois, and J. Kiser and J. MacGregor (pers. comm.) found a completely white *M. sodalis* in Kentucky; both caves were ca. 300 km from Ray's Cave. From 1985 to 2005, the population of *M. sodalis* in Indiana increased from ca. 99,000 to 205,000 individuals ($\overline{X}$ = 166,000), and the number of bats hibernating in Ray's Cave increased from ca. 16,000 to 54,000 ($\overline{X}$ = 41,500; Brack et al., 2003; V. Brack, Jr., unpubl. data). During this time, 19 albino or leucistic individuals were found statewide, with most (17) occurring in Ray's Cave. Thus, these color abnormalities occurred with a frequency of about 1/27,000 in Ray's Cave but only 1/93,000 state-wide. These rates are considerably lower than indicated by Barbour and Davis (1969).

(a)



(b)

Figure 1. Examples of *Myotis sodalis* with pelage that was partially white, including a) a white dorsal band and b) white pelage with gray smudges.

Pelage color in mammals can be a complex phenomenon, controlled by genes at multiple loci, each with multiple alleles. For example, the loci and alleles for coloration in horses are known (see Model Horse Reference: www.mhref.com, accessed 2 March 2005). The number of variations in color of *M. sodalis* that were observed indicates that pelage color for this species is not based on a single gene with simple Mendelian ratios and suggests that the trait is multifactorial. The occurrence of white-colored pelage may be an indication of successful breeding by individuals with the phenotypic expression of the trait or by carriers of a recessive trait(s). Similarly, we do not know whether the occurrence of white bats in 2005 in populations that hibernate in southern Indiana, Illinois, and Kentucky is a result of interbreeding among populations or is independent in each population. Nevertheless, for this coloration to be observed intermittently over 23 years in Indiana and 49 years in Kentucky, the gene or genes responsible are apparently maintained in the population at low levels.

Detailed studies of survivorship of *M. sodalis* have not been completed, making a comparison of white and leucistic individuals with normal-colored individuals difficult. Humphrey and Cope (1977) reported survival rates for *M. sodalis* as 75.9% for females and 69.9% for males during years 1–6 after banding, 66.0% for females and 36.3% for males in years 6–10, and 4.1% (females) after 10 years. Humphrey and Cope (1977) could not determine survivorship for young of the year, but survival was much lower the first year after marking (ca. 41%), which was attributed to low survivorship of young-of-the-year.

Survivorship of white and leucistic *M. sodalis* that we observed was low, based on the assumptions that all *M. sodalis* hibernating in Indiana were found, all white and leucistic individuals were identified during each census, and there was no movement of bats between hibernacula in Indiana and hibernacula in other portions of the range. The first white bat that we found in 1985 was 0.5 or 1.5 years of age when first found (because our sampling occurred every 2 years), and this bat was found during three subsequent visits (at 2-year intervals), indicating an age of 6.5–7.5 years of age when last seen. All other bats with white markings (disregarding the three in 2005) were not found after their initial discovery, so we found only 1 of 13 bats during a second cave visit. Our sample is small, of course, but it suggests 7.7% survivorship for young-of-the-year with color abnormalities, if one assumes that all individuals were 0.5-year old when first found. This calculated rate may be low because some bats may have been 1.5 years of age when first discovered and they may have survived an additional year before the next survey occurred. Although it is tempting to conclude that white coloration makes bats more susceptible to predation by visually oriented nocturnal predators, low survivorship during adolescence occurs in many mammalian species (Caughley, 1977). Studies of survivorship by known young-of-the-year with normal coloration are needed for comparison before a definitive conclusion can be made regarding negative effects of albinism or partial albinism in *M. sodalis*.

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

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NEWS

From Virginia:

On March 28, 2005, *Corynorhinus townsendii virginianus* was officially named the state bat of Virginia (see Jenkins, C. L. 2005 March 29. Bat soars to lofty status in Virginia: Warner reveals his poetic side. Washington Post; Sect. B:05). [submitted by Tom Kunz, Boston University -- Thanks, Tom!]

Do you have any bat-related news items? This includes news from your lab or fieldwork, or anything you think might be of interest to *Bat Research News* subscribers. If so, please send news items to Margaret Griffiths (mgriff@illinoisalumni.org).

FUTURE MEETINGS and EVENTS

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. All sessions will be held on the National University of Ireland campus, which is located near the center of Galway city. The symposium convenor is Jimmy Dunne, Department of Zoology, National University of Ireland, Galway. Details are available on the symposium web sites: **http://www.ebrs10.com** or **http://www.nuigalway.ie**

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. The local host is Winston Lancaster. All meeting activities will be held at the Holiday Inn Sacramento Capitol Plaza, where a block of guestrooms has been reserved for NASBR participants. Additional information is available on the society's web site **http://www.nasbr.org/** or you may 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. As additional information becomes

available, it will be posted on the society's web site **http://www.nasbr.org/** or you may contact Margaret Griffiths: **mgriff@illinoisalumni.org**

ANNOUNCEMENTS

Bat Fest 2005
July 29th & July 30th, 2005
Cranbrook Institute of Science in Bloomfield Hills, Michigan
Hosted by Organization for Bat Conservation

Friday, July 29th

7 p.m. to 9 p.m.: Presentation by Janell Cannon, award-winning author of "Stellaluna" and illustrator of numerous picture books. Ms. Cannon will present a humorous, enlightening, and heartwarming program about her creative process and her love for the "unloved" animals in our world. Live Egyptian fruit bats will be shown.

Saturday, July 30th

10 a.m. to 6 p.m.: On-going live animal programs, presentations by bat experts, children's activities, hands-on workshops, environmental exhibits, nature walks, gardening talks, and live animals displays.

6 p.m. to 8 p.m.: BBQ Picnic with live music.

8 p.m. to 10 p.m.: Research techniques seminar. Bat scientists will demonstrate how to study bats using mist nets, radio telemetry, and ultrasonic detection.

4th Annual Great Lakes Bat Festival
August 12th & August 13th, 2005
Pine Mountain Resort in Iron Mountain, Michigan
Hosted by
Organization for Bat Conservation, Michigan Department of Natural Resources, and
Tourism Association of Dickinson County Area

Friday, August 12th

7 p.m. to 9 p.m.: Mine Tour. Join bat researchers for a trip underground to learn about the fascinating world of mines. Live bats will be present. Mine tours are given by local mining experts.

Saturday, August 13th

10 a.m. to 5 p.m. at Pine Mountain Resort: Continuous activities, including live animal programs, presentations by bat experts, children's activities, hands-on workshops, environmental exhibits, and history and mineral talks.

7 p.m. to 9 p.m.: Bat watch at Millie Hill Mine in the town of Iron Mountain. Bat experts will set up mist nets and traps to temporarily capture dozens of bat residents that emerge from Millie Hill Mine.

BAT RESEARCH NEWS

VOLUME 46: No. 3 FALL 2005

BAT RESEARCH NEWS

VOLUME 46: No. 3 **Fall 2005**

Table of Contents

Front Cover

The logo on the front cover of this issue is from the Xth European Bat Research Symposium (EBRS), which was held at the National University of Ireland in Galway on 21–26 August 2005. The logo was designed in 1981 at the University of Bonn and is the property of the EBRS. Many thanks to the EBRS for use of the logo.

Flooding of Hibernacula in Indiana: Are Some Caves Population Sinks?

Virgil Brack, Jr.[1], Jason A. Duffey[1], R. Keith Dunlap[2], and Scott A. Johnson[3]

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Introduction

Many species of bats hibernate in caves, but unfortunately, many caves also are conduits for water that occasionally flood, killing bats. Flooding is particularly troublesome because hibernating bats are insensitive to many types of environmental stimuli (Speakman et al., 1991; Twente and Twente, 1987), so they may not arouse from hibernation and escape. Because bats spontaneously arouse only once every 10 or more days (Brack and Twente, 1985; Hardin and Hassell, 1970), few individuals are likely to be aroused at the specific time that a flood occurs, thus allowing them to escape imminent danger. Even if the noise associated with flooding or actual contact with water disturbs bats that are in deep hibernation, arousal takes 30–40 min (Thomas et al., 1990), which may be too long to allow the animal to escape rapidly rising water.

Caves that attract bats for hibernation, but flood and cause mortality, may be population sinks (i.e., the population in the cave requires net immigration to sustain itself). Both chronic removal of a few individuals by frequent flooding and infrequent or sporadic removal of a large number of bats could affect population levels, because bats have such low fecundity. Knowledge that specific caves may be population sinks for some species, including those of special interest like the endangered Indiana bat (*Myotis sodalis*), present specific managerial and regulatory challenges.

A number of flood-related catastrophes have been recorded in North America. For example, skeletons of 300,000 Indiana bats were found in a flood-prone portion of Bat Cave, Kentucky (Hall, 1962). Ninety percent of a population of 5,000 little brown (*Myotis lucifugus*) and Indiana bats was drowned in Aitkin Cave, Pennsylvania, and in Wind Cave, Kentucky, all except 370 of 6,545 little brown and Indiana bats were killed (Mohr, 1972). An estimated 150 Indiana bats drowned when debris from forest clearing was bulldozed into a sinkhole, blocking a cave's rainwater outlet, and debris that accumulated against the inside of a bat gate at the lower entrance of another cave acted as a dam, causing flooding and the death of 3,000 Indiana bats (United States Fish and Wildlife Service, 1999). In this note, we describe several instances of flooding in caves in Indiana, where mortality of bats was documented or inferred.

Bats and Flooding in Caves of Indiana

During surveys in 1991, 1999, and 2003, Mitchell Crushed Stone Quarry Cave, Lawrence County, contained 9–38 Indiana bats, 178–380 little brown bats, 41–65 eastern pipistrelles (*Pipistrellus subflavus*), and 162–224 big brown bats (*Eptesicus fuscus*—Brack et al., 2003). The nearby White River crested at 11 m on 9 January 2005, the highest level in 68 years, and on 17 January 2005, we could not enter the cave because of flooding. One month later on 17 February, floodwaters had receded somewhat, allowing us to access anterior portions of the cave. Twenty-five dead bats were found; the bodies were heavily decomposed, and most appeared as floating, amorphous, gelatinous balls of fungus. Fourteen were big brown bats, and eleven could be identified only as probable *Myotis*. Water flows sluggishly and towards the back of the cave, but there is no stream in the front. Because currents were slow, dead bats in the front of the cave probably were found near where they died. Live bats in unflooded anterior portions of the cave included only 3 Indiana bats, 90 little brown bats, 21 eastern pipistrelles, and 76 big brown bats, or 8, 32, 32, and 43%, respectively, of the numbers found during the most recent survey in 2003 (Brack et al., 2003).

Anterior portions of the cave flooded to a depth of 5–7 m, and some of the ceilings in these areas remained above the floodwaters; deeper portions of the cave, however, were entirely flooded. Nevertheless, observations in previous years indicated that few bats typically hibernated in the high areas that escaped flooding in 2005. Most Indiana bats, for example, usually hibernated deep (low) in the cave, in a section that flooded completely in January 2005 and was still impassable one month later; consequently, most Indiana bats probably were killed, with only three present on 17 February. Despite the apparent risk, many of the living bats found on 17 February were hibernating in low areas that had flooded earlier in that winter.

Ashcraft Cave, Greene County, also is near the White River. This cave contained 20, 28, and 3 Indiana bats in 1993, 1995, and 1999, respectively (Brack et al., 2003). It also contained 190, 170, and 29 little brown bats during those same years, 6 and 14 eastern pipistrelles in 1993 and 1995, and 4 big brown bats in 1993. In 2005, 13 little brown bats and two eastern pipistrelles were the only bats found. Fresh mud and debris during our visit in 2005 indicated that water had risen ca. 2.3 m earlier in the winter, which would have inundated most of the cave, including areas typically used by hibernating bats of all species, resulting in the death of most bats. We believe that declines in abundance between 1995 and 1999 also likely were caused by flooding, although specific evidence was not documented.

In some cases, the portions of a cave that flood infrequently appear to attract bats so that the population increases during years between flooding events. Binkley Cave, Harrison County, contained 84 Indiana bats and 197 little brown bats on 12 January 1997. It flooded in early March 1997, and on 10 March, only three live bats and 10 dead bats were found (J. Benton, pers. comm.). However, four years later, on 10 February 2001, nine Indiana bats and 110 little brown bats were again hibernating in this cave. Salamander Cave, Monroe County, is well known for the dangers it presents to cavers when areas near the entrance flood. In 1982, 74 Indiana bats used this portion of the cave, but only one bat ever was found during five surveys between 1987 and 2005. This decline was more abrupt and complete than for other caves in the region, and we think it was attributable to flooding, rather than disturbance caused by cavers. On 23 January 2005, we visited Clifty Cave, Greene County, and found that an area of the cave used by hibernating Indiana bats had flooded prior to our visit; only two bats were using the area. This cave was surveyed 11 times between 1982 and 2005, yielding counts of 66–575 Indiana bats, with 0–44% of the population roosting in the area that floods. Over those years, the population of bats using the cave has been through two cycles of low and high numbers. Because we did not know when or how often this cave floods, we could not directly trace these population changes to flooding, but it was clear that bats that hibernated in this portion of the cave were very susceptible to drowning. Drowned bats would be washed from the cave, leaving no evidence of the kill.

There are many caves in Indiana that routinely flood, but which, nevertheless, attract a few bats. The following are two examples. Primitive Baptist Spring Cave, Monroe County, is a low wet cave with obvious signs of flooding to the ceiling in most places. Only nine bats, including an Indiana bat, were found during a survey in 2005, but most roosted in areas where they would be killed by flooding. In 2002, Bluff House Cave, Martin County, was visited. Only seven eastern pipistrelles and one Indiana bat were discovered, but it was obvious that many portions of the cave flood. When visited in 2003, two little brown bats, two eastern pipistrelles, and two big brown bats were seen.

In some cases, alteration by man, inside or outside the cave, may contribute to flooding. At one time, Batwing Cave, Crawford County, contained 50,000 Indiana bats (Richter et al., 1978). In 1995, the entrance of nearby Big Windy Cave, which has a hydrologic connection to Batwing Cave, was enlarged and extended into the bed of a small drainage. Water entering Big Windy Cave via this drainage caused flooding in Batwing Cave to a level 11 m above normal, and in 1996, several hundred dead Indiana bats were found in the lower level of the cave, which houses about 83% of this cave's winter population (Johnson et al., 2002). The carcasses were in fresh mud, and there was other evidence of recent flooding.

There are probably many more instances of mortality from flooding, but these are likely overlooked, especially when few bats are involved. Floodwaters can disperse carcasses and deposit drowned bats in hidden locations within the cave, or the bodies may be washed from the cave. Dead bats may be buried in mud or scavenged by predators. Even when carcasses are deposited where they can be found, remains are quickly reduced to bones, and unless these form a large concentration, they are easily overlooked. After signs of a flood (e.g., debris on walls or ceilings) have diminished, carcasses or bones cannot be easily related to a flooding event. Finally, few caves are routinely entered by biologists, limiting the opportunity to discover flood-related mortality.

Conclusions

Flood-related deaths may be an important source of mortality for some North American species, especially the Indiana bat. There are 34 caves in Indiana known to have served as a hibernaculum for a least one Indiana bat during at least one winter during the last 25 years (Brack et al., 2003; V. Brack, Jr., unpublished data). Eight of these are known to have flooded, with known or inferred kills of Indiana bats. Thus, 24% are potential population sinks. Although, numbers of bats using most of these caves have been small, one cave once harbored 50,000 bats.

There are many issues with caves that act as population sinks. Should managers exclude bats from caves that flood? At what point is the sink detrimental to the long-term health of local populations or the species? Both Mitchell Crushed Stone Quarry and Ashcraft caves contain large quantities of fresh mud and silt and are situated below a landscape that is dominated by agriculture. Is flooding a result of surface activities, and have those activities converted once suitable hibernacula into death traps? If so, how can the regulatory, conservation, and scientific communities help landowners reduce flooding and the loss of bats? Finally, these caves may provide an opportunity to understand better the mechanisms of colonization and characteristics of caves that entice colonization.

Acknowledgments

We thank the many people who assisted with field studies, especially T. Sollman, and A. King for reviewing the manuscript. The Indiana Department of Natural Resources funded most field studies.

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Partial Albinism in the Lesser Mouse-tailed Bat, *Rhinopoma hardwickii*

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Albinism is a rare phenomenon that occurs in all vertebrate groups. Although albinism has been recorded in a number of species of bat (e.g., Bekker, 1989; Buys et al., 2002; Uieda, 2000; Van Laar, 1994), we could find no previous reference to its occurrence in the lesser mouse-tailed bat, *Rhinopoma hardwickii*. On 1 May 2004, we were looking for roosting sites of bats in villages located between Jodhpur (N26°17′59 and E73°02′02) and Bikaner (N28°01′22 and E73°19′13) in the Thar Desert, when we discovered a colony of ca. 350 bats that were roosting in the semi-dark portion of a dilapidated building in the village of Mevasa. This colony was composed of both the greater mouse-tailed bat, *Rhinopoma microphyllum kinneari*, and the lesser mouse-tailed bat. Three of the lesser mouse-tailed bats were partial albinos, with varying degrees of white fur on their body and/or head; however, the face, ears, limbs, and flight membranes appeared normal (Fig. 1). The behavior of the leucistic bats seemed generally similar to that of individuals with normal coloration, although the abnormally colored bats appeared somewhat more sensitive to the disturbance caused by our visit, making frequent flights in the roost and looking more disturbed when lights were pointed at them. Albinistic individuals of some avian species, such as the large grey babbler, *Turdoides malcolmi*, also seem more disturbed by human presence than normal-colored birds (Sharma, 2003).

Acknowledgment.—We thank the Department of Science and Technology, Government of India, for providing financial assistance to conduct this survey.

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Figure 1. Partial albinos of the lesser mouse-tailed bat in India.

Xth European Bat Research Symposium

The Xth European Bat Research Symposium (EBRS) was held at the National University of Ireland in Galway on 21–26 August 2005. The symposium was attended by 201 participants from 30 countries: Armenia 1, Australia 1, Austria 1, Belgium 2, Bulgaria 2, Canada 1, Croatia 7, Czech Republic 11, Estonia 1, Finland 3, France 8, Germany 14, Greece 2, Hungary 1, Ireland 26, Italy 4, Lithuania 4, Netherlands 8, Norway 4, Poland 8, Portugal 5, Romania 5, Russia 3, Slovenia 4, Spain 8, Sweden 1, Switzerland 4, Ukraine 2, United Kingdom 50, and U.S.A. 10.

Members of the organizing committee were James Dunne (convener), Sinead Biggane, Conor Kelleher, Colin Lawton, Ferdia Marnell, Kate McAney, Emma Teeling (all from Ireland), Peter Lina (Netherlands), Stéphane Aulagnier (France), and Simon Mickleburgh (United Kingdom). Wieslaw Bogdanowicz (Poland), Thomas Kunz (U.S.A.), Paul Racey and Susan Swift (both from United Kingdom), and Kate McAney and Emma Teeling (both from Ireland) were members of the scientific committee. The abstracts below were edited and formatted by Anthony Hutson (United Kingdom) and Peter Lina.

The XIth EBRS will be held in Romania in 2008. Lithuania presented an invitation to host the XIIth EBRS in 2011.

ABSTRACTS
Xth European Bat Research Symposium

The following abstracts are listed in alphabetical order by first author. Many thanks to Anthony Hutson and Peter Lina for editing and formatting the abstracts. Any errors that may have been introduced in the preparation of the abstracts for publication are inadvertent, and I ask that you please accept my sincerest apologies. Margaret A. Griffiths, Editor

LONG-FINGERED BATS, *MYOTIS CAPACCINII,* PREY ON LIVE FISH

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In 2003, the authors reported evidence of piscivory by long-fingered bats, *Myotis capaccinii*, having detected fish remains – mainly scales - in faeces collected from four individuals captured entering a cave during the night. In order to assess the significance of this finding we worked in two ways. First, from October 2003 to April 2005 we collected faeces from 121 bats caught in different seasons in three localities, including that in which piscivory was reported. The analysis of a sample of 142 faeces showed no presence of identifiable fish remains. Secondly, in April 2005 we performed an experiment with long-fingered bats kept in captivity in a flight tent where a 1.5 m^2 artificial pond was constructed. We captured bats leaving their roost, and released them into the flight tent. Each night increasing amounts of fish were released into the artificial pond and also the water depth was lowered. We studied the behaviour of bats using infrared light torch, camcorders and ultrasound detectors. Additionally, we checked the feeding of each bat through keeping them in individual bat boxes and analysing their faeces. We experimentally demonstrated that this species is able to prey upon free-swimming fish when they occur in high densities and shallow waters: at least five of eight bats attempted to fish, plunging strongly onto the water surface with their hind feet; moreover, four of eight individuals succeeded and ate captured fish, as demonstrated by fish remains found under their resting places and in faeces.

PRELIMINARY RESULTS OF SPRING FEEDING BEHAVIOUR IN *MYOTIS CAPACCINII* IN THE EASTERN IBERIAN PENINSULA

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The diet of *Myotis capaccinii* (Bonaparte, 1837) in the Eastern Iberian Peninsula was investigated by faecal sample analysis. Faeces were collected individually from 17 bats in April 2004. As the foraging sites of individuals were known by a simultaneous radiotelemetry survey, we could estimate the insect availability in the foraging sites. Prey availability in places where foraging activity was recorded and in places where it was not recorded, was determined by insect trapping methods that imitated the foraging behaviour of the bat species. Insect samples where numerically dominated by small dipterans, especially of the family Chironomidae, but many other taxa were also present. Only some of the available orders were found in the diet, including Diptera (e.g. Chironomidae and Tipulidae), Lepidoptera, Trichoptera, Coleoptera, and Araneae. The diet is dominated by water-related insects, mainly dipterans, but typically terrestrial prey were also present (e.g. moths and spiders). Four possible sources of prey are discussed: emerging imagos from aquatic pupae, swarming insects over water, drowned arthropods and aquatic insects with activity over the surface. The selection of foraging sites by bats was linked to prey abundance, since foraging sites had greater availability of prey than places were foraging activity was not recorded.

HABITAT USE BY FOREST BATS ON MARK TWAIN NATIONAL FOREST, MISSOURI

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In the eastern U.S. National Forests is assessing the status of forest bats and their habitat selection. As part of this effort, four species of bats including *Myotis sodalis* and *Myotis grisescens* (both Federally listed as Endangered) were fitted with radio transmitters to determine roosting and foraging habitat selection. Location data was collected for 60 individuals for from 3 to 22 days to observe roosting and foraging behavior. Using a Geographic Information System (GIS) habitat use of each species was evaluated. Characteristics including home range, landcover within home range, habitat characteristics of each location, and roost descriptions are evaluated.

OBSERVATION OF POSSIBLE MALE ADVERTISEMENT CALLS MADE BY GREATER HORSESHOE BATS, *RHINOLPHUS FERRUMEQUINUM*, IN TWO WINTER ROOSTS

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Ultrasound calls from a colony of *Rhinolophus ferrumequinum* in a cave in Devon, south-west England, were recorded in early October using a time expansion bat detector and a digital recorder left in the cave for two consecutive 24-hour periods. Time markers were included at hourly intervals. Similar recordings were made of a *R. ferrumequinum* colony in a loft in southwest Wales for two 17-hour periods overnight during late October and three 24-hour periods in early April. In addition to echolocation calls at 83-84 kHz there were ultrasound social calls in the 15 to 29 kHz range similar to those previously recorded in a west Wales loft from late April until early October, when it was used as a nursery roost (Andrews and Andrews, 2003). Calls that had not been discriminated previously

were also recorded at both winter roosts. These were ultrasound social calls characterized by a long trill during which the frequency oscillated up and down around a mean. The characteristics of these calls and the reasons for believing that they may be the male advertisement calls of the species will be discussed.

Reference: Andrews, M. M. and Andrews, P. T. (2003) Ultrasound social calls made by greater horseshoe bats *(Rhinolophus ferrumequinum)* in a nursery roost. *Acta Chiropterologica*, 5 (2): 221-234.

DIRECTED SOUND EMISSION BY ECHOLOCATING BATS

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Many bat species that use frequency modulated echolocation determine the elevation of an object returning an echo from the relative intensities of the different frequencies in the echo (references below). For this method to be efficient the frequency components in the bat's cry must have a similar angular distribution. There is evidence that this is the case for several vespertilionid species and this has implications for the range of frequencies recorded using bat detectors.

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BATS ON POSTAGE STAMPS: ONE DECADE LATER

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For the centenary of bats on postage stamps, a comprehensive survey censused 79 stamps depicting stylised bats and 133 stamps with portraits of 56 bat species. One decade later, rejecting 56 stamps issued non-officially, the numbers reach 112 and 248 stamps respectively! Stylised bats were issued by the postal administrations of China (7 stamps symbolising fortune), New Caledonia (6 stamps issued for various festivals), and of several countries for events such as Halloween (5) or the anniversary of Dracula's father (4). For identifiable bats, the largest number of issues come from Africa (31) and continental America (25), far above Europe (15), Oceania (14) and Antilles (10); contrary to the previous period the Indian Ocean islands issued a small number of stamps (4 vs 19). Pteropodidae are still dominant (35) over Vespertilionidae (28), Phyllostomidae (22) and Rhinolophidae (10). A total of 13 families have been illustrated, including for the first time Rhinopomatidae (1) and Thyropteridae (1), as well as two recently validated families: the Hipposideridae and Miniopteridae, the last being depicted for the first time anyway. A total of 63 species and 47 genera have been illustrated, including recently identified species such as *Pipistrellus pygmaeus* and *Myotis punicus.* The most frequently depicted species are *Pteralopex acrodonta, Desmodus rotundus* and *Rousettus* aegyptiacus (5 issues each). Concerning the ecology and behaviour of bats, stamps are still poorly informative. Specialised feeding habits are the topic of some issues, and they are visible on some others. A Mexico-Canada joint issue is dedicated to a long-distance migrant, *Lasiurus cinereus*. Day roosts are sometimes shown, with special mention of a stamp from the Netherlands Antilles depicting the location of several species inside one cave. Social and reproductive behaviour are ignored, and most stamps depict bats hanging or flying alone.

REVISION OF THE WEST PALAEARCTIC SPECIES OF BAT BUGS: GENUS *CIMEX* (HETEROPTERA: CIMICIDAE)

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The Cimicidae is a cosmopolitan family of the true bugs (Heteroptera) and contains more than one hundred species classified in about 25 genera. All the species are obligate parasites of birds and mammals, including man. However, bats are generally considered as the original hosts and about two thirds of cimicid species are associated with them. Reliable information on the West Palaearctic *Cimex* species is surprisingly scarce. The vast majority of studies deal with the biology, physiology and even cytology of the most common species, *Cimex lectularius,* Linnaeus, 1758, but almost no modern data are available on its host specificity and coevolution. For other taxa of the genus *Cimex,* Linnaeus, 1758, the information is much poorer, of course. Since the monograph of the group by Usinger (1966), the value of morphological variation has not been analyzed and the same is true of the taxonomic status of particular taxa, especially those parasitic on bats. The present poster reports on the current project that is intended to change the situation and provide detailed information on the evolution and phylogeny of the West Palaearctic *Cimex.* I have started to collect new data on morphology, bionomics, host-relationships for particular local populations throughout Europe, and their life cycle in relation to their hosts, and to supplement this with sequencing data for several molecular markers. As an essential prerequisite of the study is a detailed sampling of the taxon, extensive both in its geographical coverage and the spectrum of host species, I seek the co-operation of bat specialists from throughout Europe. For that purpose the poster will be supplemented with information on these topics in a leaflet and with sampling equipment.

IS *COLEURA SEYCHELLENSIS* STILL THE RAREST BAT IN THE WORLD?

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The only microchiropteran endemic to the granitic Seychelles, the sheath-tailed bat, *Coleura seychellensis,* has declined over past decades, and is critically endangered. Using bat detectors, the islands of Mahé, Praslin and La Digue were surveyed to establish the current distribution of the bats. Although two new roosts were discovered on Mahé, no bats were observed on Praslin and La Digue and the range of *C. seychellensis* appears to have contracted in the last two decades. A total of 19 *C. seychellensis* were counted emerging from three roosts in boulder caves on Mahé during 18 evenings of observations. The bats showed a clear preference for foraging in coastal habitat, some of it anthropogenic. The echolocation calls were also characteristic of bats feeding in open habitat. This study provides no evidence that *C. seychellensis* is dependent on forest or wetland for foraging. Dietary analysis indicated that *C. seychellensis* feeds on Coleoptera, Lepidoptera and Diptera. A public education programme to highlight the consequences of roost disturbance is suggested.

FIRST DATA ABOUT THE INTENSITY OF AUTUMN MIGRATION OF NATHUSIUS' PIPISTRELLE, *PIPISTRELLUS NATHUSII*, IN SOUTHEAST LITHUANIA

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Nathusius' pipistrelle is the most numerous migrating bat species in Lithuania as well as in several other parts of Europe. The species migrates from and across Lithuania in southwestern direction to its hibernation areas. As known from various sources, wind turbines may have negative impacts on migrating bats especially in areas with flying corridors. The planning and establishment of new wind farms require more detailed data about spring and autumn migration patterns of bats, such as flyways, duration, and intensity, and how weather conditions influence these patterns. Such data can be collected by various methods such as visual and ultrasound observations, the use of bat boxes and mist-nets, and by long-term marking with rings. Each of these methods has its advantages and disadvantages. The main goal of our project is to investigate the occupancy rate of bat boxes by bats during autumn migration in order to study the above mentioned migration patterns. We are also trying to find how efficiently networks of bat boxes in woodlands of protected areas can be used by bat researchers for migration studies on bats as well as how bat boxes can contribute to the increase in suitable bat roosts. Our studies were carried out in 2004 in the Verkiai regional park situated in the southeastern part of Lithuania. A total of 72 bat boxes were erected in four different forest types (spruce, pine, deciduous, and mixed), 18 boxes in each forest type. The boxes were attached to trees at 4-6 metres above the ground, in each case 3 boxes to one tree, respectively facing south, east and west. After erection, the boxes were checked every 10 days, and after the appearance of the first migrants every 3-5 days. The first bat was found on the 2 August, the last ones on the 29 August. *Pipistrellus nathusii* only used the boxes in the deciduous and mixed forests. South-facing boxes were preferred by 95% of the bats, west-faced by 3%, and east-faced by 2%. The number of individuals in each box varied from one to eight but usually clusters of 3-5 individuals were found. The highest occupancy rate of the boxes was in the period of 16-22 August. The first data about the occupancy rate of bat boxes by *Pipistrellus nathusii* during autumn migration in Southeast Lithuania show that the use of bat boxes combined with long-term bat marking can be an important method to carry out bat migration studies.

ACTIVITY PATTERN OF THE SOPRANO PIPISTRELLE, *PIPISTRELLUS PYGMAEUS*, REVEALED BY RADIO-TRACKING

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In 2004, between 16 June and 11 July, the changes in foraging and roosting activity of lactating female *Pipistrellus pygmaeus* were studied by radiotelemetry. For 25 nights, 11 females were radio-tagged in the field in southeastern Moravia. Differences in the level of roosting and flight activity were statistically significant between three divisions of a night. On most nights each female visited a minimum of one night roost, and five of them regularly visited two roosts during one night. On average, the females occupied a roost 3.7 times per night. After parturition, distances between the night roosts and day roosts increased. The number of used night roosts declined towards weaning. Four females visited night roosts more than one kilometre from the day roost, with a maximum of 1,400 m. Time spent in a night roost did not differ during the lactation period. During lactation, when the distances from a roost to foraging grounds were the shortest, the longest flight was over 1,700 m. Six studied females flew to foraging grounds more than one kilometre from the day roost. From the beginning of lactation, some females visited male roosts. After emergence from a day roost, females flew directly to night roosts and visited them several times during the night. We suppose that females moved their young to night roosts.
This study was supported by the grant No. 206/02/0961 of the Grant Agency of the Czech Republic "Situation of *P. pipistrellus* superspecies in the Czech Republic" and the grant No. MSM 0021622416.

ARE CHANGES IN INTERNAL ROOST TEMPERATURE A GOOD REASON FOR BAT MOVEMENT?

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Many previous studies have shown that a range of species of bat switches their roost several times during the summer season. Some authors suggest significant correlation between changes in microclimatic conditions in roosts and roost switching. The changes in occupation of three bat boxes by individuals of Pipistrellus pygmaeus and internal microclimatic parameters of the bat boxes were studied in a floodplain forest. Fluctuations of bat activity in bat-boxes were monitored by passive IR monitors. Data loggers continuously recording temperature and humidity were situated under the lid of each bat box. Generalized additive models (GAMs) were fitted to assess the impact of microclimatic precursors on the presence of bats. During pregnancy and lactation, changes in internal humidity related more closely to the fluctuation in bat numbers than did changes in the internal temperature. Analyses of variance show differences between the climatic parameters and the number of bats in particular bat boxes and the reproduction periods.
This study was supported by the grant No. 206/02/0961 of the Grant Agency of the Czech Republic "Situation of P. pipistrellus superspecies in the Czech Republic" and the grant No. MSM 0021622416.

GENETIC STRUCTURE OF GREATER MOUSE-EARED BAT, *MYOTIS MYOTIS*, POPULATION IN THE MORAVIAN KARST AND ITS SURROUNDINGS

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This study concerns the genetic structure of greater mouse-eared bat, *Myotis myotis*, populations. Altogether, 40 sequences of the mitochondrial control region were obtained from 10 summer maternity roosts of *Myotis myotis* in the Moravian Karst region, Czech Republic, and one from Slovakia. Of the 40 sequences, 38 were identical with the haplotype H1, occurring throughout Europe. One sequence corresponds to the haplotype H32, found in Poland. Both of these belong to haplogroup A. The last sequence is a new haplotype, never found before, which is closely related to H35 from haplogroup D from Greece. This result supports the hypothesis about decreasing genetic variability along the direction of expansion (south-north) and also outlines another possible route of colonization from southern areas. In addition to this, we have found a new nucleotide repeat (CAACA) 2-11x; however, its utilization for population studies is not clear and demands further investigation.
This research was supported by the grant of the Grant Agency of the Czech Republic No. 206/01/1555.

TOWARDS THE ROOT OF THE VESPERTILIONID TREE: A NEW BAT FROM CHINA

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Traditionally, Vespertilionidae, the largest family of bats, presents a complicated puzzle to phylogenetic studies and classification. Molecular data, now available for nearly all genera (31) and almost 200 species of the group, has resolved convincingly the true content of major suprageneric clades. Nevertheless, the topology of deep divergences is still unstable in certain respects, particularly with reference to the use of different molecular markers. Thus, a consensual tree of all the phylogenies so far proposed is not fully resolved. Theoretically, the problem could be addressed by robust information at the root of the tree with the addition of a taxon close to the basal divergences of the group. Quite recently, we discovered such a taxon (a new genus and new species) in Central China. It is a very

small bat reminiscent of a pipistrelle in outer appearance (small pointed auricles, blunt tragus, epiblema), but with a series of outstanding differences (funnel-like auricles, tragus with hook-like basal emargination, long hairs of a woolly appearance, M/1,2 nyctalodont, M/3 myotodont, large unreduced incisors, fossa of upper molars with broad distal extension instead of metalophus but with prominent paralophus, complete premolar row with moderately reduced P3/3, ribs 4 and 5 fused at sternum etc), i.e. a mosaic of the character states otherwise considered diagnostic for particular vespertilionid genera. The sequence of the complete cytochrome *b* gene obtained from the bat was compared with that of 85 other species of vespertilionids and analyzed with the aid of several phylogenetic techniques. The bat was found to be a sister taxon to all extant *Myotis* and *Kerivoula*. It results in some changes in topology of the family tree and supposedly also to current views on the orientation of phylogenetic morphoclines in several traits traditionally applied to vespertilionid taxonomy.

THE BAT FAUNA OF THE ISLAND OF SOCOTRA, YEMEN

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Socotra is a Yemeni island in the Indian Ocean situated ca. 400 km to the south of the Arabian Peninsula and ca. 250 km to the east of the Somalian coast. It covers an area of about 3,100 km^2, with the highest point over 1,500 m a. s. l. Bats are considered the only indigenous mammal group on Socotra. The bat fauna of the island consists of only four species and shows biogeographic relations to both Africa and Arabia. The most common bat on Socotra is *Rhinopoma hardwickii*; it is distributed in all parts of the island. Around 20 sites of occurrence of this bat have been recorded at lower and middle elevations. According to traditional taxonomy, Socotran populations fit into the range of variation of its Afro-Arabian form, *R. h. arabium*. Rather less frequent is *Asellia tridens*, which is known from eight sites at low altitudes. The systematic position of this bat is uncertain; it probably represents a separate species, *italosomalica*. The occurrence of *Rhinolophus* aff. *clivosus* on the island is restricted mostly to higher elevations. It is a rare bat species on Socotra, up to the present only found at six sites. The Socotran population of this bat differs from both African and Arabian conspecifics, and therefore the island populations deserve at least a separate subspecies status. *Hypsugo ariel* (= *bodenheimeri*) is the rarest bat species on Socotra; so far only four individuals have been found in four sites at lower altitudes. Individuals from Socotra differ from those of Africa and Arabia in coloration and morphology and therefore the taxonomic status of the Socotran population remains in question.

RESOURCE PARTITIONING BETWEEN THE CRYPTIC SPECIES *MYOTIS MYSTACINUS* AND *M. BRANDTII* IN THE U.K.

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Recently, much attention has been given to the ecology of cryptic species because they provide us with an excellent opportunity to study how morphologically similar species partition resource use. Unlike most cryptic bat species *M. mystacinus* and *M. brandtii* have different evolutionary histories and are more closely related to other *Myotis* species than to each other. We aim to determine whether *M. mystacinus* and *M. brandtii* have similar foraging ecologies and behave as predicted by their ecomorphology. This will be achieved by comparing their habitat use, diet and morphology. Faecal analysis shows that *M. mystacinus* and *M. brandtii* have a broad diet (Simpson index 0,140 and 0,088 respectively), comprised mostly of Diptera and Lepidoptera. A proportion of their prey is gleaned from diurnal prey groups such as Brachycera and Cyclorrhapha and non-flying arthropods such as Araneida. Both species show seasonal differences in their dietary diversity and composition. Preliminary results from radio tracking are presented to explore relationships between diet and habitat use.

CHARACTERISTIC FEATURES OF MATERNITY ROOSTS OF *MYOTIS MYOTIS* AND THE SURROUNDING HABITAT

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The principal objective of this study was to identify those features that characterise the roosts of *M. myotis*, and that may determine the selection of roost sites. In total 187 buildings of various types (mainly churches) were checked for the occurrence of bats and 17 maternity colonies of *M. myotis* were found. The population of adult females living in the area under study (Moravian Karst, CZ) was estimated to be ca. 4,000 individuals. Intercolony movements of bats were detected. The buildings used by bats were detached, mostly (88%) higher than the surrounding houses and uninhabited. Roosting sites were usually located in lofts (82%), 64% of which were higher than 5 m, and 3 sites were in church towers. The most common construction materials used for the roofs were tiles (65%) and metal (29%). We quantified the percentage cover of 4 habitat types: open area (e.g. fields, grassland), woodland, urban area and water bodies within 2 km of the maternity roosts. We found no significant preference for any habitat type (Spearman's correlation), although the colony size was negatively related to the percentage cover of urban areas. Distance to the periphery of the village or town, to the nearest woodland and to the nearest water body or water course was measured from a map. Four roosts were directly in the outer edge of a village and the average distance to the periphery was 146 m. On average the nearest woodland was 334 m and water 251 m from the roost.

HABITAT SELECTION, FORAGING ACTIVITY AND DIET OF THE LESSER HORSESHOE BAT, *RHINOLOPHUS HIPPOSIDEROS*, AT A MATERNITY ROOST IN THE SOUTHWEST OF IRELAND.

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The lesser horseshoe bat, *Rhinolophus hipposideros*, is the only member of the Rhinolophidae to occur in Ireland. Here, it is at the most northerly point of its European distribution. The Irish population is estimated at between 9,000 and 10,000, making it internationally important. This study details investigations of the foraging behaviour, habitat preferences and diet of the species at one of the largest known maternity roosts in Europe. The roost, situated at Dromore in County Clare, is owned by the Heritage Council and is a designated Special Area of Conservation (SAC). During the summers of 2001 and 2002 twenty-one lesser horseshoe bats, twenty females and one male, were fitted with transmitters weighing less than 0.4g. Data, successfully gathered from sixteen of these bats, were used to determine foraging areas, home range and habitat preferences. Information was also gathered on commuting routes and night roosts used by the bats. The radio-tracking data were analysed using a GIS program, MapInfo, and add-on programs to determine habitat selection. Diet was recorded by faecal analysis of samples gathered weekly over a twelve-month period. The results show that lesser horseshoes selected mixed broadleaved woodland, riparian woodland and associated riparian habitats for foraging. Habitat edges such as tree lines, hedgerows and stone walls were used as flight lines to navigate from the maternity roost to the foraging sites. Night-roosting behaviour was an important social activity recorded mostly in bats radio-tracked during the pre-hibernation stage. The habitat preferences recorded through the radio-tracking study were reflected in the ecology of prey categories, as revealed through diet analysis. The diet changed seasonally: in summer the main prey consumed were nematoceran Diptera, Trichoptera, Neuroptera, Lepidoptera, Pscoptera and Hemiptera. In winter, dipteran suborders Nematocera and Cyclorrhapha dominated the diet, with Trichoptera and Lepidoptera present in much reduced quantities. The maximum distance travelled by a tagged bat was 3.3 kilometres recorded during the pre-hibernation period. Bats

displayed unimodal or bimodal activity in pre-parturition, changing to multimodal activity in late lactation and pre-hibernation. This study has important implications for the conservation of lesser horseshoe bats in Ireland. Recommendations for habitat management include the identification and protection of foraging habitats, particularly broadleaved woodland and riparian habitats close to roosts, as well as the maintenance of hedgerows, tree lines and stone walls that act as commuting routes linking roost sites to foraging areas.

ANCIENT DNA: LESSONS FROM THE PAST

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Under certain conditions small amounts of DNA can survive for long periods of time and be used as substrates in the polymerase chain reaction (PCR) for the study of phylogeny and population genetics of extinct plants and animals. About 20 years ago, DNA sequences were separately described from the quagga and an ancient Egyptian individual; what made these DNA sequences exceptional was that they were derived from 140- and 2400-year-old specimens. More recently, ancient DNA (aDNA) has been used to study phylogenetic relationships of protists, fungi, algae, plants, and higher eukaryotes such as extinct horses, cave bears, woolly mammoths, the marsupial wolf, the moa, the giant eagle, and Neanderthal. In the past few years, this approach has been extended to the study of infectious disease in the ancient mummies from Egypt and South America, suggested a butchery pattern indicative of a human population under resource stress, revealed dietary habits of ancient animals, and helped to understand how climatic change impacts biological diversity. However, the field of aDNA is still regularly marred by erroneous reports, which underestimate the extent of contamination within laboratories and samples themselves. An improved understanding of these processes and the effects of damage on aDNA templates has started to provide a more robust basis for research. DNA sequencing of the entire mitochondrial cytochrome *b* of *Myotis myotis* sensu lato in our molecular laboratory allowed the comparison of aDNA sequences (dating back to ca. 830 years BP) with those of modern bats to assess their genetic relationship. Initial results have revealed surprisingly complex population histories, and indicate that modern studies may give misleading impressions about even the recent evolutionary past.

USE OF AN ARTIFICIAL HEDGEROW AS A FLIGHT PATH BY LESSER HORSESHOE BATS: A FIELD EXPERIMENT AND ITS IMPLICATIONS FOR CONSERVATION

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In a fragmented landscape animals have to cross unsuitable habitat. Slow flying bat species often commute in the cover of vegetation corridors, probably to avoid predators. Can newly created linear structures be used as corridors so as to direct bats over green bridges? We connected a roost of the endangered bat species *Rhinolophus hipposideros* to its main forested foraging ground by installing a 200 m long linear structure of bushes in containers, so as to provide a cover between roost and woodland. Bats' use of this structure was monitored with ultrasound detectors and IR-video equipment. Over the six weeks of the experiment a significantly increasing amount of the bat population ($n = 280$ individuals) used the newly offered flight path. However, the maximum proportion of bats following the corridor was 20% (mean ± SD = 12 ± 2%). Bats flying towards the new hedgerow emerged earlier and returned later to the roost than those bats using another flight path. By enabling the bats to extend feeding activity at dusk and dawn the «artificial hedge» may exert a positive effect on bat energetic balance and, ultimately, fitness, especially since insect prey abundance peaks at that time of the day. Newly created corridors may thus be readily used by bats and function as «time and energy optimizers».

PRELIMINARY DATA REGARDING CRANIOMETRIC CHARACTERISTICS OF SIBLING BAT SPECIES IN ROMANIA

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The present study aimed to investigate three pairs of sibling bat species that occur in Romania (*Myotis myotis / M. blythii, Myotis mystacinus / M. brandtii,* and *Plecotus auritus / P. austriacus)*. In searching for the best discriminative characteristics enabling sibling species identification within Romanian bat populations, statistical analyses were performed on the morphometric variables of the skull. Geographical variability within each pair of sibling species was established by comparing specific cranial features and other measurements of the species in Romania and in adjacent European regions. The poster also gives a brief description of the present situation of sibling bat species in Romania and of their distribution. The old distribution data (recorded before 1950), more recent distribution data (recorded after 1950 until now), as well as the location of the analysed specimens, are distinguished on the maps.

TAXONOMIC REASSESSMENT OF SMALL MOUSE-EARED BATS (*MYOTIS*) OF VIETNAM

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Small long-footed mouse-eared bats, commonly referred to as the "*longipes*" group, are perhaps the most difficult to identify among the South East Asian representatives of the genus *Myotis*, notorious for its taxonomic complexity. Until the late 1990s, this group was thought to contain only one South East Asian species (*M. longipes per se*), but was recently found to be more diverse and widespread, with two newly described species (*M. csorbai* and *M. annamiticus*) and a number of records of significant range extensions made across the region. An analysis of bat collection material from Indochina suggests that historically there has been some confusion in the identification of these bats, caused by a prominent trait (small canines) they share with *M. siligorensis*. Nevertheless, Vietnamese specimens of *M. siligorensis* differ significantly from all representatives of the "*longipes*" group in both cranial and external qualitative characters, as well as bacular morphology, and show closer similarity with *M. muricola*, although still being specifically distinct from the latter. Both metric and qualitative characters indicate that the nominal forms *alticraniatus* and *sowerbyi*, originally described as subspecies of *M. siligorensis* have distinct affinities with the "*longipes*" group. Specimens morphologically resembling the type series of "*M. siligorensis alticraniatus*" were found recently in several localities across Vietnam. No significant morphological variation was found between these localities. It is proposed that *M. alticraniatus* should be considered a valid morphologically distinct species similar to *M. annamiticus*. A study of a small series of *M. alticraniatus* from the Vietnamese Central Highlands suggests the existence of two sympatrically occurring morphologically distinct forms separated by ca. 2% genetic distance.

MOLECULAR ECOLOGY AND CONSERVATION GENETICS OF LEISLER'S BAT, *NYCTALUS LEISLERI*, IN IRELAND

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Leisler's bat, *Nyctalus leisleri*, is a species of particular interest in Ireland. Across most of its range, which extents over UK and most of Europe, the species is relatively rare and considered vulnerable in many parts, with the exception of Ireland, where it is relatively common. Indeed, Ireland is considered to be the European stronghold for the species and is thus internationally important from a conservation viewpoint. Despite its obvious importance, however, very little is actually known about Leisler's bat population structure, ecology and dynamics. Here we present the preliminary results of an ongoing comprehensive molecular-based study (microsatellites and mtDNA) of

Leisler's bat, which aims to provide essential information urgently required for the rational conservation of this unique species throughout its natural range.

HABITAT PREFERENCES OF VESPERTILIONID BATS IN A LOWLAND LANDSCAPE IN MID-CORK, SOUTHWESTERN IRELAND

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From July to September 2004 over ten nights a study was conducted in a 2 km^2 area of Mid-Cork to assess the habitat preferences of *Myotis mystacinus*. Bat activity was quantified by acoustic surveys using a Bat-box duet detector within specific habitats along a transect. Overall bats avoided conifer woodland and intensive grassland and selected broadleaf and mixed woodland, river and lake. *Myotis mystacinus* selected broadleaf woodland centre, mixed woodland edge, tree lines and rivers. They avoided flying in open areas such as intensive grassland and parkland and also avoided conifer woodland. Habitat management needs to concentrate on protecting the habitats selected by this species, which is possibly Ireland's rarest bat species with an estimated population of 1,000 individuals (Whilde 1993). The habitat requirements of bats could be considered when preparing management plans for commercial forests or farms under the REPs (Rural Environmental Protection scheme). Due to the avoidance of open habitats connectivity between suitable habitats needs to be maintained if *Myotis mystacinus* is to be conserved in the Irish landscape.

Reference: Whilde, A., 1993. Threatened mammals, birds, amphibians and fish in Ireland: Irish Red Data Book 2: Vertebrates, 20 -32.

MICROSATELLITE-BASED GENETIC VARIATION OF GREATER MOUSE-EARED BAT, *MYOTIS MYOTIS,* POPULATIONS IN THE CARPATHIAN BASIN

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In order to demonstrate the existence of a significant level of genetic variation between greater mouse-eared bat, *Myotis myotis,* populations of the Carpathian Basin, we sampled 80 individual bats from three colonies in Romania (Fusteica cave, Esküllő cave and a church in Vasláb village) and one colony in Hungary (a church in Kelemér village), the locations being representative for the Carpathian Basin. The individual samples were genotyped for six nuclear microsatellite loci (A13, B11, C113, D9, E24 and G25). The loci C113 and B11 are homozygous in the majority of individuals (lowest mean heterozygosity overall). The loci A13 and E24 have the highest mean heterozygosity overall, but as in the former case, the values vary between colonies. The single colony from Hungary has the lowest genetic polymorphism. There are different levels of genetic diversity between the Romanian colonies, but compared to the colony of Kelemér, they all have significantly higher levels of genetic diversity, and are more polymorphic. Our results indicate a high level of genetic variation between the colonies of the Carpathian Basin. Further work will include sampling bat colonies from Ukraine and Poland, as well as partial sequencing of the *cyt b* gene in all colonies, in order to investigate the patterns of evolutionary relationships between colonies, and to demonstrate (or not) the role of the Carpathians as a barrier to gene flow.

BATS IN THE BUILT ENVIRONMENT: HOW BAT RESEARCH IS APPLIED TO MITIGATING THE IMPACT OF DEVELOPMENT

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Bats and their roosts are protected under European legislation as the decline in their numbers has been such that some species are threatened or endangered. With the loss of natural roosts, bats increasingly use churches, bridges, barns, houses, and other buildings and so must co-exist with humans. The discovery of bats using buildings intended for demolition or redevelopment can be a source of conflict, especially if their presence had gone unnoticed in the pre-planning stage. Development may impact on bats and their roosts in several ways, including contravening their legal protection. In England, derogations from the provisions of the Habitats Directive 1992 are permitted through a licensing system administered by the government under the Habitats Regulations 1994. In order to minimise the short and long term impacts of development, developers are legally obliged to put in place a mitigation and compensation package that is a condition of any licence. Mitigation measures usually attempt to retain, or provide an alternative to, the original roost, which is then monitored post development. In the face of increasing development, sustaining bat populations is challenging and relies on research to assess the effectiveness of mitigation, and refine bat mitigation advice provided by conservation practitioners.

ASSESSING THE IMPORTANCE OF COLONIAL BAT ROOSTS: A QUANTITATIVE INDEX TO OPTIMIZE CONSERVATION EFFORTS

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One of the most important issues in preserving biological communities is the establishment of areas with special interest for conservation. Caves may concentrate high biological richness when sheltering several cave-dwelling bat species. Considering that the economical and human resources that can be assigned to preserve bats and their roosts are limited, it is necessary to set priorities that enable the optimization of conservation efforts. With the aim of assessing the importance of different colonial cave-dwelling bats roosts, a quantitative index is hereby proposed. The index is based on a summation of the relative size of local populations of each species present at one site, weighted by their degree of threat [$I= (\sum n_i \cdot Thr_i/N_i)\ 100/\sum Thr$]. Thus, the index includes three important parameters in species conservation: species richness, regional relative abundance and degree of threat. The index can also be used to compare the status of colonies through time. It has been proposed to support roost conservation strategies in the Comunidad Valenciana (Eastern Spain), but it could be implemented elsewhere.

FACTORS TO CONSIDER IN DESIGNING LONG-TERM SURVEILLANCE PROGRAMMES FOR BATS

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Effective bat conservation relies on gathering information to identify changes in populations that are of conservation concern. The UK National Bat Monitoring Programme (NBMP) has collected surveillance data on bats since 1996

and produces annual population trends for 10 of the 16 bat species resident in the UK. The main surveillance methods employed by the NBMP are:
1. bat detector transect surveys in the open countryside and along waterways;
2. hibernation site surveys;
3. counts of emerging bats at summer maternity colonies. Where possible, the NBMP applies two monitoring methods for each species, in order to identify the most reliable and cost-effective method for the long-term.
Preliminary results indicate that, for some species, the methods produce comparable and robust trends but, in others, the methods used result in different trends for the same species. Possible reasons for this are discussed in relation to species-specific behaviour. The NBMP data are collected by volunteer surveyors and factors that might result in survey bias, such as bat detector type and surveyor experience, as well as other factors such as temperature and date have been analysed and the results discussed. Although these are preliminary results the findings could have important implications for anyone wishing to design bat surveillance programmes.

EFFECTIVE LONG-TERM MONITORING USING FREQUENCY-DIVISION BAT DETECTORS

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Frequency-division bat detectors are ideal for long-term monitoring of bat activity, because of their low data-storage and power requirements. Systems based on Anabat detectors are increasingly used to monitor bat activity under a wide range of conditions and for extended periods, providing year-round, all-night coverage. Data management quickly becomes an issue when multiple detectors are deployed for extended periods, despite the inherent efficiency of frequency division. Automated identification is an essential tool for long-term monitoring, because data quickly accumulates to the point where manual examination is no longer feasible. Although automated identification is still in an early stage of development, it can easily be used to identify distinctive call types and is also useful for scanning large datasets for calls indicating the presence of rare or infrequently recorded species. Even low rates of successful identification are useful, because of the large samples attainable. This talk highlights some of the issues influencing the effectiveness of long-term acoustic monitoring, illustrates how bat detectors have been successfully deployed for this purpose, and shows examples of results obtained.

DOES THE EXTENT TO WHICH RESOURCES ARE PARTITIONED DIFFER BETWEEN TWO BAT GUILDS IN THE UNITED KINGDOM?

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Although bats form one of the most speciouse groups of mammals, as a group they are remarkably uniform in terms of body plan and, in the case of temperate microchiropterans, their broad-scale diet. It has generally been considered that fine- scale resource partitioning is the driving force behind speciation in this group; however studies have produced a number of conflicting results. This is likely to be due to a combination of two factors: first, most studies have only focused on sub-sets of particular bat communities in a given area and hence some members of the foraging guild are not represented; second, measuring the characters that may reflect resource partitioning (whether morphometric, behavioural or dietary) is extremely difficult and can be prone to bias. This poster will highlight the objectives of this research, which will focus on determining the extent to which resources are partitioned by using stable isotope analyses. This technique has been embraced by ecologists studying the foraging ecology of other animal groups and has provided important information where conventional approaches have failed. Given the successful application of this technique elsewhere, we believe that this research will provide unique and valuable insights into the foraging ecology of bats in Britain and Northern Ireland. Also, the ubiquity of bats in rural and agricultural areas means that such findings are likely to directly inform conservation and agri-environment initiatives in this region.

CONTRIBUTION TO THE KNOWLEDGE OF THE BAT FAUNA OF THE BIOKOVO NATURE PARK

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The aim of this study, conducted by the biology student association (“BIUS”) as a part of the “Biokovo 2002 Project”, has been to collect data related to bat populations in the Biokovo Nature Park. The research was conducted as part of an inventory led by the Public Institution “Nature Park Biokovo”. The echolocation sounds of flying bats were detected using a bat detector. Bats were trapped using mist-nets set next to ponds, the source of drinking water for bats in summer. Upon capture of the animal its gender was determined and basic morphological characteristics were measured, including body mass, length of forearm, tragus and thumb claw. Finally, the animal was photographed and the species determined. Between 15 June and 23 June 2002, a total of 55 bats were trapped, measured and determined at four different locations on the southern side of the Biokovo mountain. A total of 10 bat species was identified, six of which are new species for this area: *Myotis blythii*, *M. emarginatus*, *M. mystacinus*, *M. nattereri*, *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, the total number of bat species identified in the Biokovo Nature Park is 13. Members of the genus *Plecotus* have not been determined with certainty. Bats from the *austriacus* clade belong to either *Plecotus austriacus* or *Plecotus kolombatovici*. A single bat of the *auritus* clade could be a member of either *Plecotus auritus* or the recently described species *Plecotus microdontus*. Additional morphological and genetic studies based on a larger number of bats are needed to determine which species of the genus *Plecotus* live in the area of the Biokovo Nature Park.

SEX OR FOOD – THE CHOICE IS YOURS: THE RELATION OF SWARMING ACTIVITY AND MASS CHANGES

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From 2001 to 2004 we carried out investigations in three underground sites: 2 caves in the Kraków–Czestochowa Upland and 1 mine site in the Sudety Mountains. Surveys were carried out during spring and autumn. For the autumn only, analysis of BCI (body condition index) changes was carried out for the most common species: *Myotis nattereri*, *M. daubentonii*, *Plecotus auritus* and *Barbastella barbastellus*. We found that there is no correlation between a bat’s activity during the swarming period and its BCI. We observed differences in sex/age categories. The most obvious results were gained for adult males in all investigated species. Individuals lose mass during their period of highest activity and deposit fat tissue just before hibernation time. It could indicate support for the mating hypothesis of swarming activity.

REGRESSIVE TRENDS IN EVOLUTION OF SOME DENTAL CHARACTERS IN VESPERTILIONINAE (MICROCHIROPTERA)

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Simplification of teeth structures and, in consequence, loss of some types of teeth were typical trends in evolution of various vespertilionine bats. Decrease in size, simplification, and exclusion from the toothrow are the most common

regressive transformations. For example, $P^3/$ was well developed at Palaeogene bats, such as *Icaronycteris* or *Stehlinia*. Later, the proportion of genera with reduced $P^3/$ increases. These teeth are missing in the majority of modern bat genera, while the species of *Myotis* have very variable $P^3/$. All stages of their reduction are known at different *Myotis* species from almost normally developed (*M. bechsteinii*, *M. ikonnikovi*) to completely absent (*M. ridleyi*, *M. rosseti*). High intraspecific variation of $P^3/$ size is also known. Moreover, these teeth can even be absent in individual specimens of other *Myotis* species. Probably it is the re-expression of an atavistic structure. On the other hand, *Pizonyx*, a bat closely related to *Myotis*, has increased $P^3/$. Similar trends can be reconstructed for a number of other dental characters (loss of $P/_3$ and $P^2/$, distal regression in $M^3/$, simplifications in masticator surfaces, etc.). Two main explanations are possible for regressive trends in bat dentitions, namely negative selection and unlimited accumulation of harmful mutations not being eliminated by the stabilising selection. The selection mechanism is expected for unwanted characters, while the mutation mechanism can be possible for unused characters. Both these mechanisms could act in evolution of bat dentition, but the typical patterns of regressive transformations (primarily the increase in the variation of vestigial characters) agree better with the mutational mechanism than with the selection mechanism.

SIZE AND SHAPE VARIATIONS WITHIN A GROUP OF CLOSELY RELATED SPECIES: *MYOTIS MYOTIS* (BORKHAUSEN, 1797), *MYOTIS BLYTHII* (TOMES, 1857), AND *MYOTIS PUNICUS* FELTEN, 1977: A GEOMETRIC MORPHOMETRIC ANALYSIS

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Our knowledge of the systematics and the evolution of Chiroptera in Europe is still in progress as shown by the recent discoveries of new complexes of species. From an evolutionary perspective, these complexes are interesting because they allow the study of mechanisms of speciation. In addition, they allow us to understand better how morphological differentiation takes place at different levels of the speciation process. The three large *Myotis* species, namely the greater mouse-eared bat, *Myotis myotis*, the lesser mouse-eared bat, *Myotis blythii*, and the Maghrebian mouse-eared bat, *Myotis punicus,* provide an interesting example of such a complex in the West Palaearctic. *M. myotis* and *M. blythii* are partly sympatric while *M. punicus* lives in North Africa and in nearly all Mediterranean islands. Published molecular analyses provide a partial evolutionary framework useful to interpret the patterns of morphological differentiation among these 3 species. However, all studies of the skull, which integrates different evolutionary pressures, using traditional morphometrics did not succeed to discriminate these taxa, and therefore did not help to understand their phenotypic evolution. The recent developments of geometric morphometrics provide biologists with a complete set of morphometric tools more visual and powerful than those of traditional morphometrics. The present work concerns the analysis of 3D landmarks (homologous points) describing the skulls of these three species. Geometric morphometrics allows the separate analysis of the patterns of size and shape variabilities of the skull within and between these three *Myotis* spp. The accent was put on *M. punicus*, still a poorly known taxon, for which recent molecular studies indicated a clear genetic differentiation with respect to the two other species. At the intraspecific level, the origin and the evolutionary significance of morphological differentiation between the insular and continental *M. punicus* highlighted during our morphometric analysis are discussed within the phylogeographic framework provided by the molecular studies.

CHANGES IN THE FORAGING ACTIVITY OF THE SEROTINE BAT, *EPTESICUS SEROTINUS*, AND OTHER BAT SPECIES IN COMMON FORAGING SITES THROUGHOUT THE NIGHT AND THROUGH THE SUMMER SEASON

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A study of the foraging activity of bats was conducted in the lowlands of Central Poland. The study area comprised 30 km² of agricultural landscape bordered by a large river and a broad, predominantly coniferous forest of a national park. Bat activity was recorded with the help of ultrasound detectors in repeated, all-night sessions, carried out at 25 sites located in the five habitat types distinguished in the study area. The presence of a large maternity colony of serotine bats in the centre of the study area ensured that at least for this species all the sites were easily accessible. According to expectations, in all of the study sites bat activity fluctuated markedly through the night. Unexpectedly, however, in many foraging sites the activity of serotine bats showed only one peak (in the evening), while in other bat species the expected pattern of two activity peaks (in the evening and in the morning) was usually observed. The seasonal changes in the activity of serotine bats were also in some cases different from those observed in other bat species. The five habitat types under study differed with respect to the pattern of changes in bat activity through the season and through the night.

THE IMPORTANCE OF LONG-TERM MONITORING OF BAT POPULATIONS

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Biological monitoring, here understood as regular and systematic recording of organisms, has been applied to bats in various ways. Examples are selected with the aim of displaying the diversity in monitoring that, directly or indirectly, concerns bat populations. Important data on longevity, migration tendency, and changes in bat numbers resulted from large scale bat banding programmes. Results of long-term netting or trapping of bats at the seacoast and of monitoring based on the survey of bat boxes are discussed. There is a large variety of other monitoring targets, including the foraging activity of bats, collecting and analysing bat droppings, and recording the species and numbers of bats killed by wind turbines. Most monitoring programmes have been focused on changes in numbers of individuals within large summer and winter roosts. In 1991, the Co-ordinating Panel for the Conservation of Bats in Europe held a meeting where methods of monitoring bats were discussed and a programme for monitoring bats in Europe was suggested and published. A much larger workshop was held in 2002 to examine the topic of monitoring populations of bats in the United States. Monitoring has also become part of the agenda of EUROBATS and has been dealt with in the newsletter Eurobat Chat. The paper ends by giving examples of results of long-term monitoring of bats hibernating underground. In most cases the numbers of hibernating bats increased over the last 25 years when the individuals were censused without marking or similar disturbance. It appears that no general monitoring standard can be applied to all regions, all situations and all species. In spite of this, both internationally suggested monitoring schemes and national programmes are important to focus on particular target problems and/or species.

ROOSTING ECOLOGY OF THE GREATER HORSESHOE BAT, *RHINOLOPHUS FERRUMEQUINUM* (MAMMALIA, CHIROPTERA), OF CRETE, GREECE

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The preliminary results of the first study on the roosting ecology of bats in the southernmost insular area of Europe are presented here. A colony of greater horseshoe bats in a cave in central Crete was monitored for 10 months and observations were made on the seasonality of the occupancy of the site and the activity of the bats. The number of bats present, their position inside the roost, their activity and time of emergence were recorded on a weekly basis. Trapping was carried out every 4 weeks and the reproductive state of the captured animals was assessed. Moreover, the captured bats were marked and their site fidelity and movements to other roosts were studied. The seasonality and the effect of climatic conditions on the roosting patterns of the greater horseshoe bats of Crete are investigated and compared to the existing knowledge from other populations within the species' range.

COEXISTENCE OF *RHINOLOPHUS MEHELYI* AND *R. EURYALE*: A PRELIMINARY STUDY

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The sibling species *Rhinolophus mehelyi* and *R. euryale* have overlapping distributions. However, where the two species share the same roost site, colony sizes tend to be highly asymmetric, suggesting interspecific competition may occur. The small differences in the echolocation features of *R. mehelyi* and *R. euryale* would not be expected to encourage dietary divergence between the two species. Thus, where both sibling species occur in simpatry, niche differentiation through habitat partition should guarantee stable coexistence whenever prey is not limiting. Otherwise the two species would compete and eventually one of them would disappear. Data on individuals of *R. mehelyi* and *R. euryale* from a shared breeding roost of Southern Spain showed that aspect ratio and wing loading was higher in *R. mehelyi*, which may limit its ability to cope with a high level of clutter. Accordingly, telemetry data from the same colony supported the concept that *R. euryale* foraged more frequently in cluttered environments than *R. mehelyi*. Results show some degree of niche differentiation between the two species, and suggest that as conditions change from one species' optimal range (e.g. by elimination or substitution of some vegetation units) its ability to obtain an adequate share of resources might decline through competition from the species better suited to the new conditions.

DISTRIBUTION AND ECOLOGY OF CHIROPTERANS OCCURRING IN ARMENIA

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We investigated the distribution and ecology of Chiropterans inhabiting Armenia with the purpose of proposing measures of protection for those species. Until now 27 species of Chiropterans are recorded in Armenia and this year we found a new species. Most probably it is *Myotis bechsteinii*. Bats in Armenia live in natural rock niches, caves

and building crevices in towns and villages. Many of them prefer karst caves. The southern part of Armenia is especially rich in caves. Seventeen out of eight hundred and twenty caves in Armenia form labyrinths, the longest of them being Arjer, Mageli, Chustup Katar caves, which are more than 2,000 m long. In these caves some species of bats *(Rhinolophus ferrumequinum, R. mehelyi, Miniopterus schreibersii, R. euryale, Plecotus austriacus,* and *Barbastella leucomelas)* live, breed and hibernate. Bats in Armenia live not only at the lowest altitudes (550 m above the sea level), but also at higher altitudes of up to 2,500-2,800 m. Human factors influence the bats living in Armenia. Large groups of tourists were being taken into the largest caves without permission or control in winter, thereby waking hibernating bats, and caused their mass deaths. For this reason many caves have been closed. Our research showed that the numbers of *R. mehelyi, R. euryale, Myotis nattereri, M. schreibersii,* and *B. leucomelas* have decreased, therefore these species were registered in the Red Book of Armenia.

DOES GEOGRAPHIC VARIATION EXIST IN THE ECHOLOCATION CALLS OF BRAZILIAN FREE-TAILED BATS, *TADARIDA BRASILIENSIS*?

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Some studies have demonstrated variation in echolocation calls among different geographic populations of the same species, while other studies have not. Within the United States, Brazilian free-tailed bats are currently divided into two subspecies - *Tadarida brasiliensis cynocephala* in the Southeast and *T.b. mexicana* in the West, and in the past these groups have been recognized as separate species. Their recognition was originally based on behavioural differences between the taxa, including roosting habitat, colony size, and migratory tendency. However, all genetic data show no geographic structure and indicate the two groups share a common gene pool throughout North America. Echolocation is an important sensory process in bats that will be shaped by both local ecology and evolutionary patterns of population genetic structure. The objective of this study was to determine if geographic variation exists in the echolocation calls of Brazilian free-tailed bats and to interpret these finding with reference to known behavioural and genetic patterns of the two subspecies. Echolocation calls were collected from known, light-tagged individuals at 17 sites throughout the range of *Tadarida brasiliensis* in the United States. Echolocation call structure does not differ between *cynocephala* and *mexicana* subspecies. However, call structure was significantly different between populations of *mexicana*. At Carlsbad Caverns National Park in New Mexico, calls were similar in duration and bandwidth to those collected at other sites, but were higher in frequency. Preliminary observations indicate this frequency change may be an adjustment to avoid local interference from high frequency insect noise that was not present at other locations. I am currently conducting playbacks of insect noise to free-flying bats to test this idea.

A STUDY OF BATS (CHIROPTERA) FROM AN URBAN AREA OF OSLO

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During the summer of 1993 a project was carried out to survey bats in an urban township of Oslo in Norway. Bats live in close relation to human activity, thus making human activity influential on bat distribution and survival. Using bats as an indicator might therefore give information on the environmental health of this urban area. The project was carried out as an assignment for the Center for Development and the Environment of the University of Oslo. This project's 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 various habitats' importance for the respective species. Of the total amount of surveyed individuals, *Eptesicus nilssonii* constituted over 90 percent. Østensjøvannet had a small foraging population of 10 to 20 individuals of *Vespertilio murinus*. The remaining species were recorded in very low numbers, and only in association with Lake Østensjøvannet or its immediate surroundings. However, all species except *Nyctalus noctula* are found regularly in the region. *Plecotus auritus* was expected, 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. Nevertheless, Lake Østensjøvannet seems to stand out with reference to 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 more than 60 % of all the bats found within the entire investigated area of Oslo! This strongly indicates the importance of wetlands for bat diversity and density including 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 the *Nordre Øyeren Biological Station* (NØBI) initiated a national atlas of bats. This was encouraged by the poor information that then existed on the distribution of bats in Norway, and through the responsibility that was given to *NØBI* to collect data for the European mammal atlas (EMMA), and the lack of interest amongst other organizations. Mapping the distribution of bats in Norway is a national project that was initiated by *NØBI*, and later taken over by the *Nordic Chiroptera Information Center* (NIFF). All observations are registered in a database (*BatBase*). It consists of over 10,000 observations, and is updated continuously. The objectives of the bat atlas were:
a) to map the distribution of bats in Norway;
b) to carry out a project that all members of NIFF can participate in;
c) to gather data as a contribution to the EMMA project, which was organized by *Societas Europaea Mammalogica*.
The final objective was to produce national maps divided into 10x10 square km 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 special symbols.

CURRENT STATUS OF CAVE DWELLING BAT SPECIES OF THE CRIMEA (SOUTHERN UKRAINE)

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During the summer and winter of 2004-2005 a total of 56 underground sites in the Crimea were checked. They included natural karst caves, coastal grottos, and systems of exhausted limestone quarries, and were in the mountains, coastal areas and plains of Crimea. In totally 12 species were recorded in 32 of the checked caves: including all known troglophilic species also observed previously, except for *Miniopterus schreibersii* that remains an extinct species for the region. *Rhinolophus ferrumequinum* and *Myotis blythii* are the two most abundant species, both in the number of checked sites and in the number of individuals. Maternity colonies were only found of *R. ferrumequinum, M. blythii,* and *Myotis emarginatus.* The biggest nursery colony of *R. ferrumequinum* has at least 3,050 specimens (with offspring), those of *M. blythii* at least 4,000 specimens (with offspring), and only one maternity colony of *M. emarginatus* with about 200 adult females was found. A few male summer aggregations of *R. ferrumequinum* and *M. blythii* with 100-200 individuals were also found. In winter, aggregations of *M. blythii* and *R. ferrumequinum* are also dominant. The biggest winter aggregation for the first species is about 1,500 and for the latter about 500 individuals. The results allow the identification of the current status of bats dwelling in caves in the region and the definition of key underground sites for their future conservation.

SEASONAL DIET OF THE MEDITERRANEAN HORSESHOE BAT, *RHINOLOPHUS EURYALE*, IN THE ATLANTIC REGION OF SOUTHWESTERN EUROPE

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The diet of the Mediterranean horseshoe bat, *Rhinolophus euryale,* was studied seasonally during preparturition, lactation and postlactation periods in the largest known breeding colony in northern Iberian Peninsula. Bats were harp-trapped as they returned to the day roost and were individually placed in cloth bags for a maximum of 4 hours. Droppings were collected, dried and later analysed in the laboratory. Bats were grouped in the following divisions (based on season, sex and age): 21 females and 22 males during preparturition, 37 lactating females and 6 males during the lactation period, and 25 juveniles and 28 adults during postlactation. Additionally, faeces from an unsually cool and humid summer (year 2002), when breeding was profoundly affected and spoilt, were also analysed for 14 males and 14 females. A total of 810 droppings from 167 individuals were analysed (mean 4.8 droppings/bat). The bulk of the diet by volume consisted of Lepidoptera in all seasons, representing over 90% for most divisions except in May (females 68.5%, males 70.3%), and for females during the cool summer (82.6%). A secondary quantitatively important prey item was the scarabaeid beetle *Rhizotrogus* sp*.,* although only in May (21% in volume). Percentage frequency and percentage occurrence also gave importance to other taxa such as lacewings (Chrysopidae and Hemerobiidae), and craneflies (Tipulidae). Other items appeared less frequently or in small amounts (Brachyceran flies, Psocoptera, Hymenoptera). The narrow diet of juveniles, which consisted of 97% moths by volume is also noteworthy. In conclusion, *R. euryale* can be regarded as a moth specialist, but showing some degree of flexibility.

ECOLOGICAL DETERMINANTS OF TWINNING IN BATS

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Bats generally give birth to a single young at each parturition. But, in some species, litter size can be two, and this number can reach five in *Lasiurus borealis*. A bibliographic survey was carried out to estimate the extent of twinning among 315 bat species of 17 families. Twinning has been reported as accidental in species from different families: *Eonycteris major* (Pteropodidae), *Rhinolophus hildebrandtii* (Rhinolophidae), *Megaderma lyra* (Megadermatidae), *Glossophaga soricina* (Phyllostomidae), *Pteronotus quadridens* (Mormoopidae), *Eumops perotis* (Molossidae); as occasional (low twinning rate) in *Leptonycteris nivalis* (Phyllostomidae) and *Natalus lepidus* (Natalidae). Twinning has been observed in *Hipposideros armiger* (Hipposideridae), *Cheiromeles torquatus* (Molossidae), and many Vespertilionidae. Litters of two (or more) are relatively common in the genera *Eptesicus*, *Lasiurus*, *Scotophilus*, *Nyctophilus*, *Nyctalus*, *Chalinolobus* and *Pipistrellus*. In the later, geographical variation occurs within a species, e.g. in *Pipistrellus pipistrellus,* litter size is one in England, usually two in populations of Eastern Europe. From these data, we tried to determine which ecological factors could influence twinning in bats. According to the first results, twinning is not influenced by the body size (occurring in small pipistrelles and large noctules), the size of colonies (from two to several thousand animals), the roost (trees, caves, buildings) and Éthe latitude (temperate and tropical species); but twinning has only been reported for insectivorous species. Migrations may also affect twinning, e.g. in *Nyctalus leisleri,* Irish populations (usually one offspring) are mainly sedentary, whereas populations of Eastern Europe (common twins) include long distance migrants.

FORAGING HABITATS OF BECHSTEIN'S BAT IN CENTRAL FRANCE: A POSITIVE EFFECT OF STORM DISTURBANCE?

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Bechstein's bat, *Myotis bechsteinii,* is a forest species that is difficult to study because of its cryptic behaviour. Only 11 breeding colonies are known in France, one of which is located in Limousin, in the central part of the country. It is widely accepted that optimal foraging habitat of the Bechstein's bat is large old oak-dominated forests. Woods around the roosts of the Limousin colony are however recent, highly fragmented, and 40% of them are plantations of non-native coniferous trees. Nevertheless the birth rate is high and the total number of bats in this colony has increased by 60% between 2001 and 2004. In order to explain the apparent contradiction between the demographic growth of the colony and the predominance of unfavourable habitats in the surroundings, we radio-tracked ten bats between May and August 2004. Bats foraged mainly in deciduous woodlands, which is consistent with the literature. However, further study of the third-order selection (that is, the selection of forest micro-structure) showed that the bats foraged preferentially in stands with a high structural heterogeneity. These stands were characterised by a proximity to old big trees and glades, gaps in the canopy, and an important coverage of shrubs and herbaceous plants in the understory, which are known to increase arthropod diversity and abundance. We therefore suggest that the 1999 storm that hit most of the woodlands in this area has had a delayed positive effect in enhancing their structural heterogeneity. We discuss this hypothesis in the light of current knowledge of present and past habitats of Bechstein's bat.

SEX DEPENDENT MIGRATION IN POND BATS, *MYOTIS DASYCNEME* (BOIE, 1825), IN THE NETHERLANDS

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The pond bat is one of the eight *Myotis* species native to Western Europe. Churches, houses and other buildings are their ‘summer homes’. They hunt at night for insects that fly low above the water surface. The European distribution is restricted to wetland habitats, with strongholds in the Netherlands and the Baltic States. In the Netherlands, fewer than 50 nursery colonies of pond bats are known; the total Dutch population is an estimated 10,000 animals. Dutch hibernacula are in the West of the country, in the World War II bunkers in the coastal areas, and in the South in the subterranean limestone quarries of the province of Limburg. Each year about 400 hibernating individuals are counted in the Netherlands. This research covers summer and winter periods. In summer, population dynamics are studied by monthly catching of bats on commuting routes. Each bat is sexed, weighed, its reproductive status is noted, and it is marked with a ring and a transponder. In winter, transponder codes of marked individuals are checked. During the last 4 years a total of 880 pond bats (620 females and 260 males) were marked in the neighbourhood of 17 summer roosts and 5 winter roosts. Records of exchanges between roosts are made by recaptures during summer fieldwork, visual observations in hibernacula and by automatic detection in both summer and winter roosts. In total 109 exchanges between different summer roosts were noted, 89 exchanges between summer and winter quarters, and 251 animals were recorded back in their original roosts (total number of observations = 2,800). Preliminary results show that females have a very different migration pattern from males. Seventy percent of the marked males hibernate in local winter roosts, within 30 kilometres of their summer roost. Only 3% of the marked females are found here. Long-distance migration shows very different results: 0.5% of the males and 5% of the females respectively have been found in Zuid-Limburg, Belgium, France and Germany combined. These results also reflect the sex ratio in the hibernacula, which is skewed in favour of the males or females respectively. The sex ratio is also checked by looking at genitals of free-hanging bats. These results corresponded with the ratio found through ringing results.

A NEW METHOD OF CATCHING BATS ABOVE WATER

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In 2002, 2003 and 2004 a study of the population structure of the pond bat, *Myotis dasycneme* (Boie, 1825), has been carried out in an agricultural area of the Netherlands. In order to obtain insight into the population dynamics, sex ratio and reproductive status, pond bats present on 15 commuting routes from their colony were caught every month. Although we had to catch bats almost every night for this study, not enough fieldworkers were available every night to help with the netting, so that often there was only one person per mist-net. Moreover, the most efficient places to catch bats are impractical for the researcher, as they consist of a combination of steep banks, broad channels and deep water. Therefore, we had to develop a new method for catching bats above water, which in fact consists of a combination of traditional methods. This poster describes this method and its advantages. The bats were trapped with mist-nets hung under a bridge. Mist-nets were tied between two ropes with a heavy stone attached. Each rope serves as a hoisting line. Because of its normal flying behaviour a pond bat or a Daubenton's bat, M. daubentonii, will hit the mist-net just above the water surface and get entangled. With the most common method, two persons have to hoist the lines and a third lying on his or her stomach on the bridge, has to get the bat out. With our new method one person alone can free the bat. This person sits on the string tied in the middle of a tube (an inflatable children's play tube or tractor inner tube) in the water. By treading water he or she can paddle towards the net. With feet serving for steering, he or she has hands free to handle the bat. Because the person in the tube wants to stay dry he or she wears a neoprene dry suit. We have compared 'our' method with other methods using two parameters:

1. catch efficiency (total of bats being caught of the total bats on a flyway);
2. mist-net escape % (total of bats escaping of the total of bats caught).

The new method has a significantly higher catch efficiency and a much lower mist-net escape percentage than other methods. Other advantages are: The method is applicable in a wide range of locations. One can reach the bats sooner. The net can stay on the water surface while handling a bat. A hoisted net gives free passage for other bats. Three bat researchers in tubes can handle more bats than three bat workers on a bridge of which only one can handle the bats.

PREDICTING THE DOMINANT FORAGING MODE OF MOST VESPERTILIONID BAT SPECIES – THE PROPOSAL OF A SIMPLE TOOL

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Bats occupy a variety of ecological niches around the world. Ecomorphology using a number of morphological characters from skull to wing measurements in combination with echolocation and diet analysis is still a statistically demanding and complex way of predicting foraging mode of different bat species. Molecular analysis, when added, makes the picture even more complex, time consuming and expensive. In order to simplify the picture we combined various morphological wing measurements (including one neglected for more than 100 years), the data on known foraging modes of European bat species and basic aerodynamic theory to develop an inexpensive and simple method of predicting the dominant foraging mode of several European bat species belonging to the family Vespertilionidae. The same morphological pattern observed in different bat genera seems to support the theory determining one out of three dominant foraging modes – aerial hawking, gleaning from firm surfaces and trawling from water surface. The morphological pattern of trawling bat species from different world regions was checked on wet specimens in the Natural History Museum, London, and follows the pattern of European trawling bat species. Although further research is needed we think that the proposed method could prove a valuable tool in determining the foraging mode of most bats belonging to the family Vespertilionidae.

EUROPEAN BAT LYSSAVIRUS ACTIVE SURVEILLANCE IN THE U.K. (2003-2004)

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European Bat Lyssavirus type-2 (EBLV-2) is the only lyssavirus that has been detected in the UK (n = 5, 4 bats and 1 human). There have been 13 cases in mainland Europe associated with *Myotis* bat species (*M. daubentonii* and *M. dasycneme*) and one other human case. EBLV-1 is more prevalent (>700) and generally associated with serotine bats, *Eptesicus serotinus*, plus one confirmed and one suspected human case. EBLV-1 has not been isolated in the UK. In Scotland and England (n = 29 sites) serum samples and oral swabs were collected from Daubenton's bats (n = 347), and in England (n = 6 sites) samples were collected from Serotine bats (n = 51). Antibody prevalence was determined using specific (EBLV-1 or -2) fluorescent antibody virus neutralisation tests, and tissue culture and PCR were used for virus isolation from swabs. At EBLV-2 a priori sites (n = 2), 6-12% of bats were seropositive. When all samples were included, this decreases to 3-8%. Pilot EBLV-1 seroprevalence studies suggest a low level of previous exposure in serotine bats tested, with only a single sample of 51 samples tested giving a positive result. All oral swabs tests were negative suggesting that virus was not being shed in the saliva. Future surveillance for EBLV-1 and -2 will be undertaken throughout the UK.

NATIONAL PARKS & WILDLIFE SERVICE: LESSER HORSESHOE BAT, *RHINOLOPHUS HIPPOSIDEROS*, CONSERVATION ON THE BEARA PENINSULA, CO. CORK.

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The lesser horseshoe bat, *Rhinolophus hipposideros*, is listed in Annex II of the European Union's Habitats Directive (92/43/EEC). Consequently, a number of Special Areas of Conservation (SACs) have been designated for this species in Ireland. This poster documents some of the conservation projects that the National Parks & Wildlife Service (NPWS) is undertaking within and adjacent to SACs on the Beara Peninsula, Co. Cork. These projects have focussed on providing alternative roost sites and maintaining/enhancing existing ones. They include:

1. Roofing an outbuilding to create an alternative maternity roost (the original roost in an empty cottage was lost as a result of unauthorised renovation work carried out by the owner).
2. Preliminary experimentation with the construction of two types of temporary, low-cost wooden summer roosts in Glengarriff Woods Nature Reserve (GWNR). One type is based on a box-type construction and the second type consists of modified garden sheds.
3. The creation of hibernacula in Glengarriff Harbour & Woodlands SAC.
4. Designing the conversion of a semi-derelict lodge into an office in such a way as to ensure that the summer roost in the roof is retained.

An annual monitoring programme is also in place, consisting of lesser horseshoe counts from both summer and winter roosts. Results of this monitoring will be summarised in the poster.

WINTER ACTIVITY OF BATS IN THE SZACHOWNICA CAVE (CENTRAL POLAND)

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The Szachownica cave is one of the most important bat winter roosts in Poland. More than 1,000 individuals of 11 recorded species regularly hibernate there. Our results of visual censuses carried out in the years 1993-1999 exhibit repeatable dynamic patterns of hibernating bats numbers and changes in dominance structure during winter seasons. The number of bats located increases continuously from October until March. This could possibly be as a result of bat activity inside the cave or through the arrival of new individuals from outside (migration from other roosts). To understand better this activity we started mist-netting in the years 1999-2002. Mist-nets were put in three main cave entrances for one night every month in winter seasons. We were able to identify the proportion of active/inactive bats in each date and to know the number of bats flying in and out of the cave. Especially high levels of activity (about 35-40% of individuals) were recorded during relatively warm autumn nights (November, December) with temperatures above 0 ^{o}C. The activity was much lower during frosty winter nights and varied from 10,6% to 1,7% as a minimum level. The most active species were barbastelle, *Barbastella barbastellus*, brown long-eared bat, *Plecotus auritus*, and Natterer's bat, *Myotis nattereri*. The mouse-eared bat, *Myotis myotis*, which was also one of the dominant species, was much less active during the winter. In most cases we noticed higher number of bats flying into the cave. This supports the hypothesis that they can change the winter roosts and fly outside even under the conditions of the Polish continental climate. The activity level was correlated with the temperature. Even during brief periods with night temperatures above 0 ^{o}C many bats remain active and tried to forage. We discovered defecating individuals in at least three species: *Barbastella barbastellus*, *Plecotus auritus* and *Myotis nattereri*. It shows that mid-winter flying outside the winter roost, migration and foraging are possible even in the severe winter conditions of Central Poland.

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 radio-telemetry. 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,, dropping to pre-sunset levels five hours after sunset. Bat activity ceased below an ambient temperature of 6 °C. Bats moved, on average, about 2 kilometres 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.

A BRIEF HISTORY OF THE NORTH AMERICAN SYMPOSIA ON BAT RESEARCH

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The annual North American Symposium on Bat Research is about to convene its 35th meeting. These symposia have been attended by the majority of bat biologists in North America who over the years have presented over 2,500 reports of the results of their research. To date, over 1,000 individual biologists have attended and nearly 600 individuals have made presentations. These individuals include established researchers, students, interested lay persons and many members of the present European Bat Research Symposium. In the early years, the principal areas of interest included biogeography, echolocation, ecology, genetics, physiology, and systematics. As interests evolved and new techniques became available the areas receiving the most attention have changed considerably. In this presentation titles have been arranged in each of several major categories for each 5-year period during the history of the symposium and are presented in graphic form to facilitate comparisons of the relative and changing attention given to each of the subject areas over our 35-year history. The most profound change has been in the area of technology and how it has altered the approaches taken in our research and increased the sophistication of our investigations. The continuing increase in numbers of individuals involved in bat biology bodes well for the future of bat research everywhere.

PHYLOGEOGRAPHY OF RHINOPOMATIDAE

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The Family Rhinopomatidae, traditionally considered as one of the most ancient chiropteran clades, remains one of the least known groups of the Rhinolophoidea, and one for which no relevant fossil record is available. In contrast to extensive radiation in the families Rhinolophidae and Hipposideridae, it contains only a few species for which relations and status are not fully understood. Here we supplement the information on the family with (a) the earliest datum from an Upper Miocene site (Elaiochoria 2, Chalkidiki, Greece), (b) a mitochondrial assay based on partial cytochrome b sequence, and (c) discussion on the phylogeographic patterns within the three species of the family using both molecular and morphological traits. Within *Rhinopoma hardwickii*, our analyses of Middle Eastern and North African samples recognised one major clade, with sublineages representing populations with a shallow pattern of isolation by distance. This genetic continuum contrasts with variation in the morphometric traits that revealed several morphotypes in the respective areas. Two population of *R. muscatellum* analysed (Iran, Yemen) showed a deep genetic gap (8%) that cannot exclude separation at the species level of both forms, however the potential of a genetic continuum through the range in East Arabia should be checked in further analyses. Two available specimens of *R. microphyllum* from Jordan and India were analysed; surprisingly, very small genetic distance (1.4%) is in sharp contrast to geographic distance and does not confirm a species distinctness for the Indian form *(kinneari).* In summary, populations within three *Rhinopoma* species show geographical patterns but appear to conform to a cline in genetic variation without deeper mtDNA lineages. The contrast with morphological variability points to a considerable phenotypic plasticity supposedly forced by extreme conditions of the desert habitats and a limited effect of niche partition in a species-poor genus.

IMPORTANT BAT UNDERGROUND HABITATS (IBUH) IN BULGARIA.

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Number of bats and number of species are used as criteria to identify the Important Bat Underground Habitats (IBUH) in Bulgaria. There are 93 underground habitats identified as IBUH: 89 (96%) – natural caves, 3 (3%) – artificial galleries and 1 (1%) – artificial tunnel. Fifty-two of the sites are assessed as IBUHs of national and

international importance. They are proposed as abase for the national schedule for monitoring of cave-dwelling bat species and underground habitats.

MICROCLIMATE PREFERENCES OF BAT SPECIES HIBERNATING IN THE VETERNICA CAVE

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The Veternica Cave is open for visitors and run by the Medvednica Nature Park. It is located near Zagreb, the capital of Croatia, and is one of the key bat spots for the northwestern part of Croatia. The total length of the cave passages is nearly 7,000 m with very different microclimate conditions. The first 400 m are accessible for tourists and are under the influence of external climate. There have been 14 bat species recorded until now. *Rhinolophus ferrumequinum* and *R. euryale* form winter colonies and *R. euryale* and *Miniopterus schreibersii* use the cave as summer roosts. *Myotis daubentonii*, *M. nattererii*, *M. emarginatus*, *Myotis myotis*, *Myotis blythii* and *R. hipposideros* are found in crevices or on cave walls throughout the winter mainly as solitary individuals in colder parts of the cave. During very cold weather the cave provides a valuable shelter for *M. bechsteinii*, *Eptesicus serotinus*, *Barbastella barbastellus* and *Plecotus* spp. In the winter of 2004, *Plecotus macrobullaris* was recorded in the cave and that part of Croatia in general for the first time. Data-loggers measuring temperature and humidity at 5 minutes intervals are set at 5 sites on the cave walls. Temperature, humidity and wind speed were measured near individual bats. Data on microclimate preferences of different bat species are discussed and compared with data from research conducted in the winter of 1995/1996. A significant decrease in the number of *R. ferrumequinum* and *R. euryale* has been noted and recommendations for bat conservation through sustainable cave management are offered.

SOCIAL CALLS OF *PIPISTRELLUS NATHUSII*

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Social calls of *Pipistrellus nathusii* were recorded in Southern Bohemia during the years 1999-2004. The social calls of males (regular sedentary display, and songflight), females and juveniles (recorded at maternity colonies) or individuals during particular behavioural situations (various situations during the mating season, including “advertising calls” when emerging from maternity roost) were analyzed and compared with respect to their structural design. Mating calls are generally composed of three main parts (ABC); a fourth part (D) can be added. Particular males differ in individual traits of advertising calls (especially the lowest frequency of the third call of V-shaped signals (part C), the lowest frequency of FM call (part B) and the number of components in the regular sedentary display). The fourth part of advertising calls of males (D) was produced mainly in the peak of the mating season and in sedentary display. It contains components similar to the calls recorded in maternity colonies. Part D is largely specific to individual bats and can be characterized with spectrogram shapes copying letters L, M, N, I, U, V, W. Distribution and frequency characteristics of particular types are individual-specific and several gradual transitions were noted from the fourth part (D) to the first part (A) of advertising call. Some males emitted long sequences of these signals during sedentary display interrupted by the second part (B), the second and the third part (BC) or by steep FM signals sweeping from 70 to 20 kHz with a duration of 0,6-4 ms and an interval of 5-26 ms.
In the maternity colonies I often recorded “double-note communication” and gradual transitions from short “hustle and bustle calls” during emergence to the first part (A) of advertising calls of males.

VOCALIZATION AND DISPLAY ACTIVITY IN *PIPISTRELLUS NATHUSII* DURING THE MATING SEASON

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Display activity of males of *Pipistrellus nathusii* was investigated in Southern Bohemia, in an area of 10 km^2 where two maternity colonies also occurred, during the years 1999-2004. Regular sedentary displays were repeatedly recorded in 33 sites from 40 males in addition to correspondingly numerous records of songflight and echolocation calls repeatedly recorded in close proximity to 3 sites (6 males) during whole-night observations (257.5 hours of acoustic record in total). Advertising calls of particular males were found to exhibit well-pronounced individual specificities by which the individual males were identified in later studies. Males spent more time emitting advertising calls close to their roosts in August than in July; the percentage of sedentary display was four times higher than that of songflight. In the years 1999-2001 the average amount of vocalisation was 2.3 times more frequent in August than in June (4.9 for sedentary display), in the years 2003-2004 it was 3.4 and 6.9 respectively. I observed that each male seemed to have its own pattern of switching between songflight and sedentary display during the peak of the mating season. Advertising males with roosts in close proximity (2-10 m) spent more time in sedentary display. Radio-tracking (12 to 23 September 2004) revealed that two advertising males with enlarged testes spent most time close their roosts (hunting areas within a distance of less than 1 km), whereas males with regressed testes were only recorded several times during the night and changed their day roosts regularly.

HUMAN USE OF UNDERGROUND SITES IN FORTRESSES AND ITS EFFECTS ON THEIR USE AS BAT HIBERNACULA

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The fortresses of the ‘Nieuwe Hollandse Waterlinie’ were built in the mid-nineteenth century as a strategic line of defence in the Netherlands. Although hardly ever used in war situations they were managed as a Ministry of Defence property until the 1980s. This enabled many of the underground sites in the fortresses to develop into bat hibernacula. About 25 years ago most of the fortresses were recognized as important historical, cultural and natural sites and some were given a conservation status. Some fortresses obtained a more educational and recreational function. Since site management costs of such fortresses, as well as their potential value as historic and cultural sites, put a strain on their function as mere bat conservation sites, the effects of human use on the hibernating populations were investigated. Three fortresses are compared with respect to the development of their hibernating populations in relation to their respective management. All are situated within a hotspot of hibernation for *Myotis daubentonii, M. nattereri, M. mystacinus* and *Plecotus auritus* in the central part of the Netherlands. One, Fort bij Rijnauwen, has been managed as a bat conservation site for over 25 years, the second, Fort bij Vechten, has undergone a major change in management including increasing human use of the underground sites in the last 6 years, whereas the third, Fort ‘t Hemeltje, has been intensively used for nearly 30 years but has been out of use for about 10 years now. The relative importance of the sites within the hotspot was established. For the different underground sites in the fortresses data on species and numbers of hibernating bats for a time series of respectively 9, 19 and 10 years could be reconstructed and trends relative to those in the hotspot and a larger surrounding region deduced. Data on choice of hibernation position (free or hidden) were gathered. In the winter of 2004/2005 the changes of hibernation locations of bats in the course of the winter were surveyed. From data and literature a descriptive temporal model for use of the ‘hibernacula’ by bats was developed. For all underground sites the pattern of ‘human use’ (including year round or seasonal, different forms of storage, parties, sleeping, guided tours, survival activities and optimizing the climate) was established and categorized in quality and intensity. The meta-analysis of all available data allows us to identify which disturbance factors and what seasonal timing has negative effects on the different species. We hope that from these insights specific management advice on the level of the use of individual underground sites will be possible, allowing the combination and strengthening of their function as natural (bats), historical, cultural and ecological sites.

INTERACTIONS BETWEEN AGRICULTURAL MANAGEMENT, BIODIVERSITY, AND LIFE HISTORY: BATS AND THEIR PREY AS BIOINDICATORS

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The abundance of bioindicator species is used to assess the impact of environmental changes that reduce biodiversity. The sensitivity of bioindicators to such changes is assumed, but rarely quantified. Bats and other insectivorous mammals are likely to be good bioindicators in agricultural landscapes, since their prey species are the target of agricultural management. In order to evaluate the use of bats and their prey as bioindicators, we tested their sensitivity to four aspects of agricultural intensification (increasing agrochemical use, the shift from hay to silage production, increasing field size and decreasing landscape heterogeneity). We quantified differences in abundance of bats and their prey (nocturnal Lepidoptera and Diptera) on carefully matched pairs of agricultural fields in southwest England to assess the effect of each aspect of agricultural intensification. Bat abundance was assessed by recording echolocation calls, which were identified to species using artificial neural networks. For each taxon under study we will derive a numerical index of sensitivity to each aspect of agricultural intensification. We will then relate sensitivity to life history characteristics. By thus understanding mechanisms that underlie sensitivity to environmental change, we will be able to quantify the suitability of bats and insects as bioindicators of agricultural intensification, and make recommendations for their conservation in agricultural ecosystems.

GENETIC ANALYSIS IN THE STUDY OF BATS

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Molecular methods have allowed major advances in understanding the genetic structure of bat populations. Major findings include the discovery of cryptic species, quantifying the extent of gene flow among populations, assessing colonisation patterns, estimating levels of inbreeding, and determining patterns of relatedness among colony members. Cryptic species have been discovered when sequencing studies revealed large-scale patterns of genetic divergence within bat populations previously thought to comprise single species. Genetic divergence if not always a robust method for defining species however, and evidence from echolocation call differences and subtle morphological differences can strengthen arguments for splitting species. Sequence data can be used in phylogenetic analyses to infer colonisation patterns of bats, for example to determine whether island populations evolved from single or from multiple colonisation events, and to determine historical patterns of population change. Studies using microsatellites have quantified gene flow among populations. Inbreeding has been shown to reduce survival in one study, and genetic data have been important in determining that swarming sites are important centres for outbreeding for some bats. Microsatellite studies have also been used to reconstruct pedigrees in bat populations, to quantify reproductive skew and to describe mating strategies. Overall, the genetic analysis of populations provides key information for the conservation biology of bats. Results have influenced conservation strategies for cryptic species, defined evolutionary significant units, suggested improving habitat connectivity to increase gene flow to isolated populations, and confirmed the importance of conserving key mating roosts.

SITE FIDELITY IN DAUBENTON'S BATS, MYOTIS DAUBENTONII, AS A STRATEGY TO GUARANTEE ACCESS TO RESOURCES

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During summer 2003 and 2004, activity patterns of Daubenton's bats (3 males and 11 females) were monitored using telemetry. Roost and hunting sites used by these radio-tagged animals were also identified. Our study was carried out in the Soignes forest, a "cathedral" forest covered with 65% beech trees of 150-200 years old. The study area also encloses many ponds in the forest and in the surroundings. Roosts were found at an average of 20 m. above

the ground in natural cavities. Our results demonstrated that bats were highly faithful to a roosting area. The 18 trees sheltering tagged animals were concentrated in an area of 6% of the forest, which did not correspond to the distribution of hollowed trees. All ponds in our study area were exploited by Daubenton's bats. However, "our" female Daubenton's bats monitored showed a high site fidelity to a restricted number of ponds. Only two of the ponds were used regularly whereas other ponds, highly productive and located near the roost, were never visited by "our" bats. The possibility of a discrete distribution for different groups of Daubenton's bats is discussed. Our hypothesis is that each of these groups could choose one zone in the forest as a roosting area and one or some specific ponds as hunting area.

FIRST ATLAS OF BAT DISTRIBUTION IN THE MOSCOW REGION

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While several bat specialists have published the results of investigations in the Moscow vicinity since the 1930s (A. Kuzyakin, K. Panyutin, P. Morozov, and others, including the author), there were no distribution maps of bat findings in this region. We made distribution maps for all the bat species known from the Moscow region with the use of Ozi Explorer 3.95.2. GPS Mapping Software, using only the trustworthy records. Data came mainly from zoological collections, which contain voucher specimens (primarily the collection of the Moscow Zoological Museum) and from our personal fieldwork. Most old records came from the close vicinity of Moscow, which was countryside in the first half of the 20th century and later became incorporated into a megalopolis. The total number of mapped sites is ca. 90, which does not look like much for such a large area. Most of the common species are represented by relatively many records, mainly from the central, western and eastern part of the region. *Eptesicus nilssonii* is, however, represented by a single and questionable record although this species is not rare westward of the Moscow region. Additionally, the atlas demonstrates that several districts with a total area of ca. 23.000 sq. km. (about half of the region area), and covered with very variable landscapes from broadleaved forests to forest-steppe, have not been investigated at all. Providing further faunistic investigations in the Moscow region is necessary for the elaboration of conservation measures for its bat species and their environment.

ADVANCED IMAGING AND INFORMATION TECHNOLOGY FOR ASSESSING THE ECOLOGICAL AND ECONOMIC IMPACTS OF BRAZILIAN FREE-TAILED BATS ON AGROECOSYSTEMS

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The Brazilian free-tailed bat, *Tadarida brasiliensis*, is a migratory species that forms some of the largest aggregations of mammals known to mankind. A single cave colony of this species in summer months in the southwestern United States may exceed 20 million individuals. Extrapolated to other roosting sites in the region, the local bat population of this species in south-central Texas may exceed 100 million individuals. Each night during warm months, these bats disperse over varied landscapes to feed on flying insects. Some of the insect prey includes crop pests, such as the corn earworm and cotton bole worm. Field data were collected on diet, time and energy budgets, and colony size using infrared thermal imaging and Doppler radar to assess the ecological and economic impact that these bats have on an agroecosystem. Basic ecological and physiological data, as well as predictive models are combined to assess the ecosystem services (insect consumption) provided by these bats.

GROUP COMPOSITION AND SITE FIDELITY OF BATS IN SOUTHERN FINLAND

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Very little is known about group composition or site fidelity of bats in Finland. Our study aims at answering these questions, based on ringing data from bats inhabiting wood-concrete bat boxes. Our study was started in 2004. The study area is located in Western Uusimaa, in Southern Finland. Several tens of bat boxes have been placed in the area in the eighties, and ca. twenty of them were still in their original site and in good condition. In summer 2004, a total of 23 boxes were monitored, and bats used 13 of these. Bats were found from seven of these and bat droppings from six. Three species and a total of 90 individuals were recorded. The most numerous species was *Myotis daubentonii* with 84 individuals, and other species were *Plecotus auritus* with four and *Eptesicus nilssonii* with two individuals. Bats were found mostly in groups, which varied in size between four and 32 individuals, but in six cases there was only a single bat in a box. The groups consisted of both sexes, having a higher frequency of males than females: from all bats found in 2004, 61 individuals were males and 29 females. Of the captured bats, only two were juveniles, and they were found late in the summer. Nine individuals were recaught. All of them belonged to species *Myotis daubentonii* and they were controlled only once. In 2005, more bat boxes were placed in the area. Here we present the results of our study up to now, including data from 2004 and 2005. Also conclusions and ideas for further research as well as aspects of bat roost conservation are discussed.

BAT CALLS VARY UNPREDICTABLY AMONG HAND-RELEASE EVENTS

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Acoustic characteristics of different bat species are most often determined from bats that are captured and then recorded upon release. This approach is relatively easy to accomplish, and release sites can be chosen to maximize the range of call types that can be detected from each bat released. Over two seasons, we have collected data from hand-released bats, with an emphasis on trying to determine how the endangered Indiana bats, *Myotis sodalis*, could be distinguished acoustically from the more common *Myotis* in the area. Our data show that *Myotis* calls being recorded in this way show a great deal of variation between release events. This variation could give misleading impressions of how species might differ. We analyzed our data to examine how variation between different nights and between different release sites might influence our ability to observe calls of the types most useful for distinguishing between species. Our results show the necessity of recording calls from multiple release events, and we speculate on some of the variables likely to influence the types of calls recorded when bats are recorded in this manner.

CAN PARASITIC MITES AFFECT THE CONDITION OF BAT HOSTS? THE CASE OF SPINTURNICIDAE ON THE BENT-WINGED BAT

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Bats harbor a wide range of ectoparasites, among which mites are the most abundant. The fact that mites complete the entire lifecycle on their hosts suggests that they have the potential to impose pressure upon hosts, and consequently influence their fitness and physical condition. Previous work demonstrated that mite parasitism has energetic costs for bats, but so far a clear link between mite loads and the physical condition of hosts had not been established. We have now found evidence that parasitism by the mite *Spinturnix psi* has a negative impact on the physical condition of the bent winged-bat, *Miniopterus schreibersii*. Loads of *S. psi* were studied on the bent-winged bat throughout the yearly cycle (late pregnancy, parturition, mating, and hibernation periods) in Southern Portugal. A significant impact on hosts was only detected during the parturition period, when mite loads reached their highest levels. This effect was evident in juveniles, and in both adult males and females. In general, heavily parasitized bats had the lowest body condition observed at any time of the year. This suggests that mite parasitism may result in higher susceptibility to factors like starvation, diseases, and predation, and therefore plays a potential role in the regulation of bat populations.

JUVENILE EXPLORATION BEHAVIOR AND PHILOPATRY IN THE SEROTINE BAT, *EPTESICUS SEROTINUS*

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Non-volant juvenile bats are confined to the maternity roosts of their mothers without an opportunity to become acquainted with and explore their surrounding environment before their first flight. This spatial exploration and orientation as well as the process of becoming acquainted with roosts and foraging areas must take place in the short period of time between fledging and the start of hibernation. At the same time it must allow for enough foraging time to build up sufficient fat reserves for the winter. This study is the first to examine the process of spatial exploration in juvenile serotine bats. Twenty-one juvenile *E. serotinus* from four maternity colonies in Hesse, Germany, were radio-tracked for a total of 135 nights between 1998-2001 from the time of their first flight until hibernation. The radio-tracking was complemented by light tagging of further juvenile bats and all-night roost observations as well as a mark and recapture study of adult and juvenile serotine bats (1,004 captures, 526 recaptures in 1990-2002). In addition, the unique opportunity to simultaneously radio-tag and track two pairs of mother and pup allowed for detailed case studies of mother-young behavior during an early exploration phase and revealed information unattainable via any other research method for crevice-dwelling serotine bats. For juvenile bats, a 3-stage scheme of spatial exploration is suggested:
1. practice and exploration phase, consisting of a flight practice phase, local exploration and long distance exploration (day 1 - week 2);
2. habituation and feeding phase (week 2 - 4), and
3. feeding and excursion phase (week 4 - hibernation).
The results of this study indicate some degree of flexibility via primarily independent spatial exploration by juvenile serotine bats in a species otherwise known as traditional and conservative in its roost and habitat use.

COMMUNAL NIGHT ROOSTING OF SEROTINE BATS, *EPTESICUS SEROTINUS*, IN VACANT MATERNITY ROOSTS

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Night roosting behavior of the serotine bat, *Eptesicus serotinus*, was studied at two maternity colony sites in Hesse, Central Germany, from 1997-2000. In addition to radio-telemetry (n = 49 nights), a double-faced infrared light

barrier (n = 97 nights) and video-monitoring were used. The 8 radio-tracked bats made use of 15 different night roosts on 22 occasions, the majority being in and on buildings (13), although some were on trees (2). Located night roosts were most often in or in the vicinity of the last feeding site and were frequented by individual bats for a short break (range: 2-29 min). However, temporarily unoccupied maternity roosts also served as night roosts and were visited for periods of up to 267 minutes. An in-depth study of night roosting in these temporarily vacant maternity roosts was possible via automatic monitoring devices. They revealed that night roosting at these sites was essentially communal. Adult females roosted in groups of up to 32 individuals in a temporarily vacant day roost. This night roost was used for up to 8.5 hours per night (∅ 4.2 h). The duration of the communal night roosting period varied seasonally, and large groups of bats (≥ 5) spent significantly more time in the roost at night (∅ 5.9 h) than small groups (∅ 3.5 h) or single bats (∅ 2.6 h). The use of unoccupied maternity roosts as night roosts showed a specific pattern. Several nights of individual bats or small groups checking out the diurnal retreat was followed by a large group comprising a greater part of the maternity colony using the roost as a night roosting site for several hours. After that the entire colony moved into the roost for subsequent day roost use. Thus, the function of diurnal retreats of bats cannot be restricted to their use as day roosts. They also assume an additional function as potential night roosts when the roost temporarily has no day roost function. The importance of these behavioural patterns lies in the predictive quality of nightly visits for succeeding day roost occupancy.

ECHOLOCATION CALLS OF SIX DESERT BAT SPECIES FROM JORDAN

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Echolocation calls of six desert bat species: *Eptesicus bottae*, *Hypsugo bodenheimeri*, *Plecotus christii*, *Pipistrellus kuhlii*, *Rhinolophus clivosus* and *Taphozous perforatus*, were recorded during a field trip to Jordan in October 2004. Species determination was ascertained by netting at recording sites (except for *R. clivosus*). Basic echolocation parameters (start frequency, end frequency, frequency with maximum energy, interpulse interval and call duration) are described and compared with those published in previous studies. Echolocation calls of *H. bodenheimeri*, *P. christii* and *R. clivosus* are described for the first time. The record (both echolocation and capture) of *Taphozous perforatus* from Hammamat Ma'in in the Dead Sea region represents the second record of this species for Jordan.
This research was partially supported by the Grant Agency of Czech Republic (project number 206/05/2334).

SPATIAL ACTIVITY OF MATERNITY COLONIES OF DAUBENTON'S BATS IN DIFFERENT PHASES OF THE REPRODUCTIVE CYCLE AS REVEALED BY RADIOTRACKING

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Spatial activity of maternity colonies of Daubenton's bats, *Myotis daubentonii,* from the northern part of Třeboňsko Landscape Protected Area and Biosphere Reserve (South Bohemia, Czech Republic) was studied during pregnancy, lactation and in the post-lactation period in the late spring and in the summer in 2005. In total, 16 females (6 pregnant, 6 lactating and 4 after weaning of juveniles) were fitted with radio-transmitters and followed to their foraging sites located over different water bodies (ponds, reservoirs and river). Switching of day roosts (mostly tree cavities) was also recorded. Changes in home range size, frequency of roost visitation during the night, day roost switching and alternation of foraging sites between consecutive nights are described and the results are discussed with respect to changing energetic demands of bats between particular periods of the reproductive cycle.
This project was supported by GAJU 67/2005 and the BCI Scholarship Programme.

SURVIVAL ESTIMATES OF DAUBENTON'S BAT, *MYOTIS DAUBENTONII*, AND THE NORTHERN BAT, *EPTESICUS NILSSONII*

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This study draws upon capture-mark-recapture data of *Myotis daubentonii* and *Eptesicus nilssonii*, collected between 1976 and 1988 in the caves of Piusa, South-East Estonia. The data was analysed using different programmes, such as RELEASE, SURGE and MARK, to test different statistical models and obtain estimates of survival and capture rates. Cormack-Jolly-Seber's (CJS) model did not fit the data for either species. No sexual variations could be detected in the survival rates of either species. For *Myotis daubentonii*, the annual mortality rates were age-specific, increasing in younger age and decreasing later. Average estimates of annual survival rates were 0.65 for the first, 0.82 for the medium and 0.80 for the third age class. For *Eptesicus nilssonii*, the annual survival estimates were 0.50 for the first age class and 0.67 for the second age class. The capture rate of *Eptesicus nilssonii* depends on winter severity, increasing in colder winters.

THE IMPORTANCE OF CENOTES IN STRUCTURING BAT COMMUNITIES IN YUCATAN, MEXICO

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Cenotes (from the Mayan word *dzonot*) are water sink holes formed by the dissolving of limestone. In the Yucatan Peninsula, they are the main water sources for plant and animal communities. Our project investigated the importance of cenotes for bats by comparing the community structure between forest and pastureland, with and without cenotes, in order to test the hypothesis that species composition, diversity, abundance and dominance differs significantly between sites and seasons. Five ground mist-nets, one canopy mist-net and one harp trap were set at each site. Insectivorous species were also monitored with a Pettersson D980 bat detector and BatSound Pro software (Pettersson Elektronics, Uppsala, Sweden). Community characteristics were analyzed with Species and Richness Software (Pisces Conservation Ltd). After 96 nights of work we caught 2,819 bats from 6 families and 26 species grouped into 6 trophic guilds: aerial insectivore, gleaners, frugivore, nectarivore, sanguivore and carnivore. Phyllostomids were the most abundant with 17 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'=1.47) but was not significantly different from the others investigated (randomization test at 5% Level). Our results demonstrated that cenotes increase bat diversity and abundance 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.

SETTING UP PROTECTED SITES FOR *RHINOLOPHUS HIPPOSIDEROS* IN IRELAND – A CASE HISTORY

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The Vincent Wildlife Trust began setting up protected sites for the lesser horseshoe bat, *Rhinolophus hipposideros,* in Ireland in 1998. To date, twelve sites have been secured, either by the outright purchase of the roost site, or through a long-term leasing arrangement. These sites are distributed throughout the species' range in Ireland, which is confined to the western Atlantic seaboard. This paper will describe this effort by focusing on just one site, from its discovery and acquisition, the typical programme of works undertaken after acquisition, through to ongoing monitoring and management of the surrounding habitat. The number of lesser horseshoe bats counted emerging or

within the twelve protected roosts prior to parturition in 2004 was approximately 1,900 bats, which constitutes between 19 and 21% of the Irish population, which is estimated to be in the region of 9,000-10,000 animals.

FECAL DNA LINKS THE DIET OF BATS TO AGRICULTURAL PEST INSECTS

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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. Using a conserved region of the mitochondrial cytochrome oxidase II gene (CO-II) we document the 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. Insect DNA from field-collected fecal samples from bats was cloned and sequenced, confirming the species identity of targeted moth species in the bats' diets. The use of terminal restriction fragment length polymorphism (TRFLP) analysis of amplified sequences is presented as an efficient method for species-level identification of prey DNA in bat diets. Use of quantitative PCR is explored to quantify species-specific insect DNA in fecal material. Our goal is to document the daily and seasonal consumption of pest insect species by bats in relation to the emergence and crop infestation patterns of the insects to assess the services provided by bats in the suppression of insect pest populations.

BATS IN BAT-BOXES IN PINE FORESTS OF SOUTHERN LITHUANIA

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Two hundred and fifty-two standard wooden bat-boxes were erected in four localities in pine forests of Dzukija National Park and Cepkeliai Reserve (Southern Lithuania). Two localities were in riverine forest, while the other two were in the forests with high bogs. The checking of the bat-boxes was carried out twice a year from 2000 to 2003. In total about 413 individual bats were found. *Pipistrellus nathusii* predominated (95.4%), especially during the breeding season. The other four bat species: *Plecotus auritus, Eptesicus serotinus, E. nilssonii,* and *Myotis dasycneme* were much less abundant (0.3%-2.4%). During the monitoring period the number of bats inhabiting bat boxes had a tendency to increase in riverine forests (*P. nathusii* and *M. dasycneme*). Only a small number of bats during the whole survey used bat boxes erected near the high-bogs (*P. auritus, E. serotinus* and *E. nilssonii*). Because of large maternity colonies of *P. nathusii* (up to 50 individuals in one bat box) the number of bats inhabiting bat-boxes in the summer period was 20 times higher than in autumn. The bat boxes were used as breeding roosts (*P. nathusii*), as mating shelters (*P. auritus, P. nathusii* and *E. serotinus*) and as temporary roosts during the autumn migration period (*M. dasycneme, P. nathusii, P. auritus* and *E. nilssonii*). Bat boxes in riverine pine forests near the forest roads and near the edges of nursery plantations attracted the largest number of bats.

IDENTIFYING EUROPE'S MOST IMPORTANT HIBERNATION SITES: A EUROBATS INITIATIVE

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Underground sites, both natural and artificial, are an important and threatened resource for bats across Europe. Since 1999, the Agreement on the Conservation of Populations of European Bats ('EUROBATS') has run a project to identify the most important underground sites for bats in each country so they can be protected and monitored. Data on the location of such sites and the bats that use them have been submitted by many Parties and Non-Party Range States and collected into a database, which, though not yet complete, contains details of more than one thousand sites in 19 countries. Some preliminary analysis of these data will be presented, looking at patterns of site usage and species occurrence across Europe. The international significance of such sites will be discussed and examples of conservation problems presented. The EUROBATS Agreement is a regional Agreement under the Bonn Convention that aims to encourage international co-operation on bat conservation. There are currently 30 Parties to the Agreement and interest from many other Range States. The Agreement operates through Resolutions passed by Parties and delivered through the work of the Secretariat, based with the UN in Bonn, and an international Advisory Committee that meets annually.

MANAGEMENT ACTIONS FOR THE CONSERVATION OF THE LONG-FINGERED BAT, *MYOTIS CAPACCINII,* IN EASTERN SPAIN

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An exhaustive monitoring of the regional population of the long-fingered bat, *Myotis capaccinii,* was carried out as part of the actions of the LIFE nature project 00NAT/E/7337 "Bat Conservation Plan in the Comunidad Valenciana" (Eastern Spain) funded by the EU and the regional government. The overall population in this area was estimated to be ca. 2,500 individuals that are distributed among 17 breeding roosts, most of which included less than 100 individuals. The main factors of impact affecting the species were human disturbance at roosts and inappropriate closing of caves. Transformation of riverine habitats and the use of pesticides could be reducing the numbers of its usual insect prey. Following the EU Directive 42/93/EEC, 15 breeding roosts have been included in the NATURA 2000 network, 8 of which have been protected by peripheral fences coupled with information panels. The implementation to date of a research project on habitat use will certainly improve the knowledge of its feeding areas and might guide future conservation strategies. Moreover, formal agreements between environmental authorities and cave owners have led to the establishment of 2 fauna sanctuaries. Interestingly, the Regional Federation of Speleology has become a fundamental partner in this bat conservation strategy, arguing for the protection of caves and helping in the monitoring and preservation of bat roosts. A legal document, the "Long-fingered bat Recovery Plan", expected to be approved by 2005, will protect all the 17 known breeding roosts in the Comunidad Valenciana. Over the next years, this plan will encourage better research programmes and new funding for cave owners, as well as continuity of awareness campaigns.

NATTERER'S BAT, *MYOTIS NATTERERI,* AND COMMERCIAL CONIFEROUS PLANTATIONS

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Natterer's bat is one of the least studied European bats due to the scarcity of known summer roosts, their habit of late emergence from roosts and frequent roost switching. Since they have an echolocation call of very broadband width it is difficult to survey them using bat detectors. As for most other species of European vespertilionid bats, it has been considered that commercial coniferous plantations are an inferior and poorer quality foraging habitat than broad-leaved woodland and are generally avoided by Natterer's bat. Previous work on Natterer's bat has identified semi-natural broad-leaved woodland, tree-lined river corridors and ponds as preferred areas for foraging. I studied Natterer's bat in Tentsmuir Forest, a 9,143 hectare forest on the NE coast of Fife, Scotland, that has been planted predominantly with Scots pine, *Pinus scotica,* and Corsican pine, *Pinus nigra*. In 1985, Natterer's bats were discovered breeding in out-buildings in Tentsmuir and they now regularly use various types of bat box as summer and maternity roosts. The use of bat boxes has allowed us to individually mark 353 bats since 1998. I radio-tracked 20 Natterer's bats to investigate foraging and roost dynamics over the period May-Sept in 2003 and 2004. All bats tracked used 1-3 core feeding areas within their individual home range. The mean 100% foraging areas of individual bats = 0.472km^2 +/- se 0.105. The mean 85% foraging area of individuals = 0.185km^2 +/- se 0.0056. Compositional habitat analysis of the foraging area shows that stands of mature Corsican pines are the most preferred foraging habitat and that they are used highly significantly more than their availability. In addition to bat boxes I found that the bats roost in a specific type of natural cavity in predominantly mature Corsican pines that has not been recorded before in commercial plantations. Twenty roosts were found in natural cavities in double-leadered pines whilst only two roosts were found in old woodpecker holes. These findings shed new light on how commercial coniferous plantations are a valuable foraging and roosting habitat for Natterer's bats and given the large amount of commercial coniferous forest now planted in the UK this has important implications for conservation management.

SWARMING BEHAVIOUR IN *MYOTIS DAUBENTONII* – PHENOLOGY AND RELATION BETWEEN DIFFERENT TYPES OF ROOSTS IN THE SWABIAN ALB (SW GERMANY)

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Swarming behaviour occurs in *M. daubentonii* from the end of July to mid September inside traditional winter roosts. To examine this phenomenon, 623 *M. daubentonii* have been caught in front of and inside caves in the Swabian Alb (SW Germany) by mist-netting from 1999 to 2004. Five hundred and thirty have been banded, and eight were examined by radio-tracking. The peak of swarming activity occurs in the middle of August. Four percent of the captured *M. daubentonii* were bats of the same year and only 14% of the caught females had recently raised a young. Nightly swarming activity begins almost exclusively with males flying out of the cave. Later on, other bats from outside fly in. Some of the bats flying out had obviously spent some period inside the cave in a hibernation-like state. They had a low body mass and greenish droppings without insect remains. Most bats visit the swarming site once. Only 9 of the 530 swarming bats (exclusively males) could be caught for a second time in the same swarming period. Twenty-five (4.7%) of the banded bats could be found hibernating in the swarming site in the following winters. The roosts the bats use after visiting the swarming sites (found by banding and radio-tracking) are very different. Two males were found in tree hollows, two in human buildings, these quarters were within a range of 2 km around the swarming sites, and three males in bat boxes where females still lived together with their young. These quarters had a distance of 10 to 33 km from the swarming sites. After banding 8 males flew into a tunnel-like canal that is 10 km from the swarming site, where a large colony with about 400 males and non-breeding females

exists. According to these results, swarming behaviour may, besides having physiological reasons, have the function to allow the bats to check whether the hibernacula are suitable for successful hibernation.

SWARMING BEHAVIOUR OF BATS IN HIBERNACULA IN THE SWABIAN ALB (SW GERMANY)

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Swarming behaviour is shown by many bat species from mid-July to the end of September inside traditional winter roosts. For further investigation, 2,594 bats (623 *Myotis daubentonii*, 507 *M. nattereri*, 420 *M. myotis*, 392 *Pipistrellus pipistrellus*, 333 *Plecotus auritus*, 103 *M. bechsteinii*, 95 *M. brandtii*, 83 *M. mystacinus*, 16 *Barbastella barbastellus*, 14 *Eptesicus serotinus*, 4 *M. emarginatus*, 2 *Nyctalus noctula*, 1 *P. austriacus* and 1 *Vespertilio murinus*) have been caught in front of and inside caves in the Swabian Alb (SW Germany) by mist-netting from 1999 to 2004. The peak of swarming activity differs between bat species: at the beginning of August in *P. pipistrellus*, in mid August in *M. daubentonii*, *M. bechsteinii*, *M. brandtii* and *M. mystacinus*, at the beginning of September in *M. myotis* and *M. nattereri*. Males are predominant in swarming activity. The portion of females is up to 40%, mostly less. Only in *P. pipistrellus* females amount to 63%. Most of the swarming females did not raise a young in the same year. The proportion of bats of the year is very low in most species: 15% and less, only in *P. pipistrellus* 30%. Recaptures of banded bats (*M. myotis*, *M. daubentonii*, *P. pipistrellus*) in the same swarming season are very rare, obviously swarming behaviour is a single event in the bat's year. Most of the recaptured bats used their swarming site as a hibernaculum. The nightly swarming behaviour always begins with bats flying out of the cave. Later on, other bats join from outside. Some of the bats leaving the cave show signs of long starvation (greenish faeces, low body mass), so they may have passed some period inside the cave in a state similar to hibernation. These results indicate that swarming behaviour primarily is connected with physiological reasons and/or the qualities of the swarming site and rather not with mating behaviour. Perhaps the bats are just checking the cave for the next hibernation period.

SWARMING BEHAVIOUR IN *MYOTIS MYOTIS* – PHENOLOGY AND RELATION BETWEEN DIFFERENT TYPES OF ROOSTS IN THE SWABIAN ALB (SW GERMANY)

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Swarming behaviour is developed in *Myotis myotis* from the end of July to the end of September inside traditional winter roosts. For further investigation, 420 swarming *M. myotis* have been caught in front of and inside caves in the Swabian Alb (SW Germany) by mist-netting from 1999 to 2004. Three hundred and forty-one of them have been banded and fourteen of them have been used for a radio tracking study. The peak of swarming activity lies in the beginning of September. One percent of the captured *M. myotis* were bats of the same year and 40% of the swarming females have raised a young not long ago. The nightly swarming behaviour always begins with males and females flying out of the cave, so at least some of the swarming bats use the cave as a day roost. Later on, other bats join from outside. Some of the bats leaving the cave show signs of long starvation (greenish faeces, low body mass), so they may have passed through a physiological state of hibernation. The bats visit the swarming site very seldom. Only 12 of the 186 swarming males occurred in the same swarming period for a second time at the swarming site, females however could be caught only once. The swarming bats hibernate in the same cave later on, because 37% of

the swarming bats could be found there in the following winters. The roosts that the bats use after banding or radio-tagging, are very different. Nineteen could be found in seven nursery colonies, up to 130 km away, two in tree hollows and two in buildings. Males could be found in tree-hollows (1) and buildings (2) as well as in bat boxes (1). The maximal distance between swarming site and summer roost is only 20 km in the males. Two radio-tagged bats flew into the cave and stayed there for a longer time than the tags worked without leaving it. These results indicate that swarming behaviour may have, beside physiological reasons, the goal to check the conditions of the hibernacula for successful hibernation.

FIRST RESULTS OF A LIFE-NATURE PROGRAM FOR THE CONSERVATION OF THREE CAVE-DWELLING BATS IN SOUTHERN FRANCE

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On 1 April 2004, the French Mammal Society and twelve partners initiated a four-year LIFE-Nature program in order to preserve populations of three threatened cave-dwelling bat species: *Rhinolophus euryale*, *Myotis capaccinii* and *Miniopterus schreibersii*. The program is based on a network of 26 bat roosts, which are located in 13 sites of Community importance of Southern France. It aims:

1. to study the diet of and habitat use by the three species;
2. to protect (physical and/or legal protection) 13 main bat roosts, and,
3. to inform public and local people.

During the first year of the program we confirmed the negative impact of grilling the entrance of *R. euryale* maternity colonies and *M. schreibersii* roosts. Incidentally, for the first time in France, this LIFE-Nature program has secured a deserted mine by fencing a 50 m^2 area around the entrances to protect an important roost of *M. schreibersii*. Bats from the six main roosts [*R. euryale* (3), *M. capaccinii* (2) and *M. schreibersii* (1)] were radiotracked in order to locate their foraging areas. During six two-week sessions, species studied were *R. euryale* (3 sessions), *M. capaccinii* (2 sessions) and *M. schreibersii* (1 session). Eight bats were monitored at each session. Protection of roosts was also a major activity: one roost was bought for conservation of *R. euryale*, the entrances of 3 roosts were protected by grills (*R. euryale* and *M. schreibersii)*, and management agreements were signed with private owners for 3 more roosts. Finally, public awareness was initiated by publishing articles in local or national magazines (14), organizing conferences for the 2004 European Bat Night (3), writing the scenario of a film, and preparing the draft of a leaflet.

ROOSTING ECOLOGY AND HOME RANGE OF DAUBENTON'S BAT

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To investigate roosting ecology and home range of Daubenton's bat, *Myotis daubentonii*, a radio-tracking study was carried out on the rivers Don and Urie, Aberdeenshire, Scotland. Fifteen bats, 11 females and 4 males, were radio-tracked from May to October 2004. A total of 28 day roosts were found within 1.2 km of the rivers. Most roosts (85%) were in trees. Bridge pillars and the ruins of a castle were also used occasionally as day roosts in September and October. Except during lactation, Daubenton's bats switched their roosts frequently. Five maternity roosts were located, three of which were also occupied by pipistrelle bats, *Pipistrellus* sp. Most Daubenton's bats usually foraged over the river close to their roost (<200 m), and at the same site every night, except during lactation when two sites were used, one close to and one much further away from the roost.

APPLYING GENETIC METHODOLOGIES TO PROBLEMATIC CONSERVATION QUESTIONS: FRUIT BATS IN THE WESTERN INDIAN OCEAN

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Bats are generally a difficult taxonomic group to study using standard behavioural techniques due to their nocturnal habits, mobility, large colonies and propensity for multiple mating. Genetic analysis at the species and population level can overcome many of these difficulties. We utilised genetic analyses of microsatellite and mitochondrial DNA (control region, cytochrome *b*, 12s rRNA sequence analysis) to answer conservation questions relating to fruit bats of the genus *Pteropus* in the western Indian Ocean:

1. What are the genetic relationships between the island species of fruit bats in the western Indian Ocean and how has colonisation history influenced their current distribution?
2. Have documented bottlenecks in the Critically Endangered Rodrigues fruit bat, *Pteropus rodricensis*, resulted in eroded genetic variability in this species?
3. Is the captive breeding programme for *P. rodricensis* effective in maintaining wild-type genetic variability?

Fruit bats of the genus *Pteropus* are considered 'keystone' species in island ecosystems due to their role in seed dispersal and pollination. Extirpation of fruit bats from these islands could result in a cascade of extinctions. Studies such as this are vital to ensure the effective conservation management of fruit bats in the western Indian Ocean in the future.

MORPHOLOGICAL AND ECOLOGICAL DIVERSITY OF THE WINGS IN RHINOLOPHOID BATS (CHIROPTERA, RHINOLOPHOIDEA)

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Wing structure is one of the most important features for bat morpho-ecological grouping. The goal of this work was to investigate morphological diversity of wings in the superfamily Rhinolophoidea. Fifty species of eight genera were included in the analysis.

According to wing shape Rhinolophoid species are divided into three groups:

1. broad-winged with large chiropatagium - Megadermatidae, Nycteridae, and a part of the Rhinolophidae;
2. broad-winged with small chiropatagium - most Rhinolophidae;
3. narrow-winged with small chiropatagium - Hipposideridae.

Analysis of wing structure diversity showed that the variety of form is determined by ratios of proximal and distal wing elements. The first trend of variability based on changes in proximal parts is evaluated in Hipposideridae. The second one involving variations in distal elements was observed in Rhinolophidae, Megadermatidae, and Nycteridae. Within different morpho-ecological groups of Rhinolophoidea parallel rows of wing structure variations were identified. On the other hand similar wing shapes caused by the development of different parts of the wing can be seen in the families Rhinolophidae and Hipposideridae. Possibly the main hunting strategies in Rhinolophoid bats, i.e. perchers and gleaners (Megadermatidae and Nycteridae), fluttering aerial foragers of highly cluttered space (most *Rhinolophus*, some *Hipposideros*, *Coelops*), fast flying aerial foragers of open space (most Hipposideridae, some *Rhinolophus*), are presented each by a number of particular versions based on sets of morphological adaptations revealed herein.

HAS THE CONSERVATION VALUE OF SWARMING SITES BEEN UNDERSTATED?

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Capture surveys at underground sites in southern England revealed many individuals of up to 11 different bat species 'swarming' on evenings between August and October. Subsequent studies at a subset of sites employed a variety of methods to investigate the sizes of populations of swarming bats, the area over which they were drawn, and the purpose of their visits. The results demonstrated that the conservation value of underground sites had been hitherto underestimated by hibernation counts alone, and that 'swarming sites' are of great importance to the maintenance of populations of many of the UK's bat species. Estimates of the numbers of swarming bats of three species (*Myotis bechsteinii, M. daubentonii,* and *M. nattereri*) showed that each site may be a focal point for populations numbering between several hundred and several thousand individuals depending on the species. Transfer of bats between neighbouring sites was low and the catchment areas of sites were extensive; hence disturbance or destruction of a site would be detrimental to bat populations over a large area. The order of appearance of the different species at the sites during swarming and the males' state of readiness for mating supported the theory that the bats gather to mate. Taken together, these findings suggest that 'swarming sites' are important centres for outbreeding. Effective conservation of swarming sites will benefit bat populations in the wider landscape and will work towards attaining favourable conservation status of bat species in the UK.

POPULATION GENETIC STRUCTURE OF *MINIOPTERUS SCHREIBERSII* INDICATES RECENT NORTHWARD RANGE EXPANSION IN IBERIA

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We studied the genetic structure of the Portuguese population of *Miniopterus schreibersii* with two main objectives: (i) to look for evidence of a post glacial northward range expansion, and (ii) to make inferences about social organization of the species. We examined maternally inherited mtDNA control region sequences and six bi-parentally microsatellite markers over 11 nursing colonies distributed along the Portuguese territory. Haplotype diversity of mtDNA in the northern colonies is approximately half of the diversity held by the southern colonies, supporting the scenario of the postglacial northward range expansion. Like many other species of vertebrates, during the glacial period *M. schreibersii* may have survived in the warm refugia of Southern Iberia, or was extirpated and later recolonized the Peninsula from North Africa. The parsimony network of mtDNA haplotypes shows a star-like shape: a central haplotype is abundant and found in all colonies, whereas the remaining haplotypes are specific to one or a few colonies within the same geographical region. Results were consistent with a sudden expansion in each colony. Genetic differentiation is moderate among distinct regions revealing some genetic structure at the regional level. In contrast, the preliminary analysis of the microsatellite loci shows a weak population structure, suggesting high levels of gene flow among colonies. These results can be explained by a strong male-mediated gene flow that contrasts with the phylopatric behaviour of the females.

PRESENTATION OF THE SLOVENIAN BAT NGO: SDPVN - SLOVENIAN ASSOCIATION FOR BAT RESEARCH AND CONSERVATION

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The Slovenian Association for Bat Research and Conservation (SDPVN) is a non-governmental organisation founded in June 2001; however, the members had already started working in 1998. Our main goals are to improve the knowledge of the distribution and biology of bats, to enhance and propose the protection of important bat sites and to promote public awareness about bats. In Slovenia we have 29 bat species and all of them are legally protected. To know more about the distribution and biology of bats, the members of our society are organising numerous excursions to caves, churches, castles, and many different feeding sites. We also participate in youth and student research camps in Slovenia , as well as in Croatia and Montenegro. We co-operate with other Slovenian NGOs and also with other bat groups and NGOs in Europe, especially from our neighbouring countries. Since 2002 we have been partners in the “Interreg project - Bat Conservation in the Alpine and Adriatic Region”. In Slovenia we are supporters of projects such as “Towards the designation of planned Landscape Park Ljubljansko barje”, “Interreg - Protection of amphibians and bats in the region Alpe – Adria”, and “Natura 2000”. Besides working with other NGOs, we also co-operate with governmental institutions and are consulted in the preparation of documents and legislation relevant for the conservation of bats and their habitats. Our representatives have attended the Advisory Committee Meetings of EUROBATS and other international meetings such as the European Bat Research Symposiums and ultrasound detector workshops. An important part of our work is raising public awareness. In the framework of the “European Bat Night” we have organised various activities such as night excursions for the public with bat detectors, slide presentations, photo exhibitions, and children's' puppet shows. Lectures and workshops are also organised during the whole year. Public awareness is also raised by handing out promotional materials: posters, leaflets, calendars and our newsletter.

DYNAMICS OF LESSER HORSESHOE BATS, *RHINOLOPHUS HIPPOSIDEROS,* HIBERNATING IN THE MARIJINO BREZNO CAVE (CENTRAL SLOVENIA)

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Between September 2003 and May 2004 we monitored a hibernating colony of lesser horseshoe bats, *Rhinolophus hipposideros,* in the Marijino brezno cave (central Slovenia). Bats started entering the cave in October, but their number peaked in February and March (847 individuals). Hibernation terminated gradually in April and in May. Although hibernating bats were widely dispersed, the bulk of the animals (95.7 %) were concentrated in the deepest part of the cave with an average temperature of 7.3 ºC and a mean relative air humidity (RAH) of 94.4%. The bats evidently selected warm, moist, climatically stable and unventilated parts of the cave. Since the RAH was high throughout the cave, it is unlikely to have influenced the distribution of hibernating bats. More crucial in this respect seemed to be the volume of the particular part of the cave. The temperature outside the cave correlated significantly and negatively with the number of bats in the cave only in autumn and spring, but not during deep hibernation. During hibernation bats showed some activity within the cave (cleaning, flying, mating, monitoring of the surroundings). Since environmental parameters were very stable during the entire hibernation, we assume that periodic arousals were triggered by some internal stimuli. The Marijino brezno cave is by far the largest lesser horseshoe bat hibernaculum in Slovenia. Very few other bats shared this shelter during the winter of 2003/2004: four Geoffroy's bats, *Myotis emarginatus,* one greater horseshoe bat, *Rhinolophus ferrumequinum*, one greater mouse–eared bat, *Myotis myotis*, and two barbastelles, *Barbastella barbastellus*.

STABLE ISOTOPES AND DIET: NEW EVIDENCE FOR CARNIVORY IN THE GIANT NOCTULE

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Stable isotopes have proved to be a very useful tool for establishing the trophic level and trophic relationships in several groups of animals including several bat species. Using stable isotopes of carbon (^{13}C /^{12}C, $\delta^{13}C$) and nitrogen (^{15}N /^{14}N, $\delta^{15}N$), we have tested the seasonal carnivory hypothesis in the giant noctule bat, *Nyctalus lasiopterus*, comparing isotopic values of bat blood during a complete annual cycle with those of its potential prey – insects and birds. A slight $\delta^{15}N$ and a considerable $\delta^{13}C$ enrichment during the bird migration seasons, approaching the isotopic signatures of small passerines, supports the hypothesis that the giant noctule consumes and assimilates bird prey during spring and autumn. Carbon isotopes seem to be in this case a more valuable indicator of changes in the diet, probably because fluctuations in $\delta^{15}N$ are more dependant on physiological condition or environmental variables. This study provides for the first time data on isotopic signatures of a European bat species, as well as data on annual variation of isotopic markers in mammal tissues in this continent.

THE DIET OF SCHREIBER'S BAT, *MINIOPTERUS SCHREIBERSII*, IN NORTHEASTERN SLOVENIA

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Approximately 100 individuals of *Miniopterus schreibersii* use the cellars of castle Grad na Goričkem from spring to autumn. The castle is situated in Goričko, the most northeastern part of Slovenia, bordering Austria and Hungary. Here on the western margins of the Panonian lowland, gentle slopes of non-limestone hills reach heights of between 200 and 400 m above sea level. The diet of Schreiber's bat *Miniopterus schreibersii* was investigated by analysing their droppings and culled parts of insects, which were colleted at fourteen-day intervals from March till November 2000. The analysis revealed 35 taxons of prey belonging to the classes Insecta and Arachnida. Lepidoptera dominated, having an average percent volume of 79%, constituting the bulk of the diet throughout the year. In decreasing importance in the diet were Neuroptera (mostly Chrysopidae) (9.2%), Diptera (7.4%), Trichoptera (2.2%) and Coleoptera (1.4%). The wingspan of prey ranged between 4 and 30 mm. Prey taxon diversity was lowest in July and August and highest in October and November. Food composition and observations with bat detectors indicates that Schreiber's bats hunted and fed close to forest canopies.

INTERREG III A PROJECTS "BAT CONSERVATION IN THE ALPINE AND ADRIATIC REGION" (AUSTRIA-ITALY-SLOVENIA)

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The European Union programme INTERREG IIIA has the objective to encourage co-operation between cross-border areas and co-finance individual projects between partners that are separated by a border but linked by common interests. This gave us the opportunity to continue the 'bat conservation projects' on a more solid financial basis and to enhance co-operation with colleagues from neighbouring countries. The project region comprises Austria (Carinthia, Salzburg, Tyrol), Italy (South Tyrol, Friuli Venezia Giulia) and Slovenia (Gorenjska, Savinjska, Koroška, Podravska and Pomurska regions and the local community Kamnik). The Arge NATURSCHUTZ in Carinthia (Austria) is acting as the lead partner during the period from 2003 to 2006. The goals of the project 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 programme for bat populations
· study of roost utilisation and habitat preferences to provide basic knowledge for long-term conservation strategies
· implementation of conservation measures
· assisting 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.

POPULATION SIZE ESTIMATE USING NONINVASIVE CAPTURE-MARK-RECAPTURE METHODS: APPLICATION TO LESSER HORSESHOE BAT, *RHINOLOPHUS HIPPOSIDEROS*, COLONIES

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Population size has important considerations in population biology, though its estimate is quite difficult to achieve. Here we investigate the potential of using genetic profiles obtained from faecal DNA as a basis for estimating the size of three colonies of lesser horseshoe bat, *Rhinolophus hipposideros*. A Bayesian method involving a single sampling session was used to estimate colony sizes. Among the 586 samples extracted and checked for mitochondrial DNA presence, 563 have been typed for eight microsatellites, and 534 provided a complete genotype at 6, 7 or 8 loci. These 534 samples represented 165 different genotypes that were attributed to as many individuals. Probabilities of identity were low enough ($P_{(ID)sibs} < 1.4x10^{-3}$) to ensure a reliable discrimination of all individuals and final error rates were sufficiently low (< 1%) to avoid biased estimates. For each pair colony/year, we estimated colony size and also 95 % confidence intervals. Results obtained agree with visual estimates and enabled validation of the method.

THE ROLE OF KARST IN THE MAINTENANCE OF BAT BIODIVERSITY

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Karst or limestone landscape covers 15% of the world's surface and has a distinctive fauna and flora above and below ground. The caves it contains are important refuges for bats worldwide. Selection of caves and roost sites within caves depends mainly on temperature. Air flow and light intensity are also important and to a lesser extent, humidity. In temperate latitudes bats change their positions within caves as temperature changes during winter. In the tropics, bats occupy caves with a wider range of temperatures. Some, at higher altitudes, may be cool enough to permit the bats to enter torpor, others are heated either by convection or by the body heat of large numbers of bats, which are at thermoneutrality. Despite high calcium requirements during reproduction, there is no evidence that bats acquire calcium as a result of living in karst caves. Longterm studies of the population ecology of bats are rare, but have mostly been carried out in karst caves in Europe, particularly in the Czech Republic and the Netherlands. The latter have shown that several species have undergone a steep decline in numbers in the last 50 years, some have remained stable, and one has increased. Extraordinary longevity of 37 years for a 35 g. *Myotis myotis* has also been established. Karstic areas contain large aggregations of bats in temperate and tropical latitudes, and recent work in Madagascar and Mexico reveals their importance in the maintenance of biodiversity. The demand for limestone for the cement industry is increasing, and some karstic systems and bat roosts are under threat. Others face increased pressure from ecotourism and water abstraction. However disturbance by humans entering caves is the most important proximate threat to bat populations. The erection of gates and grills at entrances often results in an increase in the number of bats roosting in caves.

MATE SELECTION BY FEMALE GREATER HORSESHOE BATS

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This bat shows delayed sexual maturity until age 2 or 3 years, and mature females produce a mean of only 5 pups in a lifetime. Variation in male reproductive is high and consistent across years, and young inbred males are less likely to survive their first winter. We therefore predict that females should be highly selective in their choice of a mate.

Sexually mature female bats occupy male territories in October and April/May, when mating is assumed to take place. However, mating pairs of bats are rarely observed in the wild. We visited 10 male territories consistently between October and May over a 5 year period to record the association of individual males and females that were caught in torpor. Microsatellite DNA analysis of pups born later at Woodchester Mansion in the following July, allowed us to determine most successful mating pairs. In this paper we use our data to address the following questions.

1. Do females that occupy a male territory in October and/or April/May participate in successful copulations with the resident male?
2. How faithful are mature females to a given male and his territory?
3. Is a male's reproductive success due to his characteristics, or factors of his territory, such as its quality as a hibernation site?

DIET COMPOSITION OF *PIPISTRELLUS PYGMAEUS* IN A FLOODPLAIN FOREST

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In 2000 – 2002 droppings were collected in intervals of ca. 2 weeks under the emergence hole of a nursery colony of *Pipistrellus pygmaeus* (Leach, 1825) dwelling in spaces under the roof of a game keeper's log cabin. The locality is situated in a floodplain forest at the confluence of the Dyje and Morava rivers (Southern Moravia, Czech Republic). In total, 27 samples of droppings (each consisting of 20 pellets) were used to analyze the food remains. In the diet 40 taxonomic groups of invertebrates were found. As expected, small dipteran insects were the main food items in which Nematocera dominated (60 per cent of all items). Besides Chironomidae and Ceratopogonidae, a high percentage of nematoceran eggs was also recorded. The relatively high frequency of Brachycera was surprising (7.2 %). Further frequent food items were Trichoptera (9.4 %), Hymenoptera, Coleoptera and Sternorrhyncha (ca. 3.5 % each). No between-year differences (2000-2002) in the percentages of particular prey groups was found (ANOVA, $F = 5.78$, $p = 0.158$, $df = 48$). The study period was divided into four parts with respect to bat reproduction, i. e. pregnancy (until June 15th), lactation (June 16th - July 13th), post-lactation (July 14th - August 11th) and movements (after August 11th). A significant fluctuation during the season was found only in Nematocera (F-test, $F = 2.54$, $p = 0.048$, $n = 27$), nematoceran eggs ($F = 9.81$, $p = 0.001$, $n = 27$), Muscoidea ($F = 2.60$, $p = 0.046$, $n = 27$), Tipulidae ($F = 6.75$, $p = 0.001$, $n = 27$) and Heteroptera ($F = 6.47$, $p = 0.001$, $n = 27$).
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LONG-TERM CHANGES IN THE NUMBERS OF BATS HIBERNATING IN MASS HIBERNACULA ON THE TERRITORY OF MORAVIA (CZECH REPUBLIC)

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In Moravia (eastern part of the Czech Republic), important bat hibernacula exist and large numbers of bats hibernate in some of them. Regular winter censuses of bats have been carried out at such sites for tens of years. In total, 6 hibernacula are evaluated with respect to the development of bat populations. Similar trends in the development of numbers of hibernating bats were recorded in the mine galleries „Pod Jeleni cestou“ near Mala Moravka (Jeseniky Mts., N-Moravia), in the Katerinska cave, Sloupske caves, Byci skala cave, Ochozska cave (all in the Moravian Karst, C-Moravia); and in the Na Turoldu cave (S-Moravia). While *Myotis myotis* and *Rhinolophus hipposideros* dominate in the limestone caves of the Moravian Karst, the galleries near Mala Moravka are characterized by a high bat species diversity with several dominant species. The Na Turoldu cave is considered the most important hibernaculum for *R. hipposideros* in S-Moravia. The numbers of bats decreased or showed irregular fluctuations up to the 1970s, whereas since the 1980s they have increased continuously. This trend is highly significant in *M. myotis* and significant in *R. hipposideros*. In the galleries near Mala Moravka *Eptesicus nilssonii*, *Myotis mystacinus* or *M. brandtii*, *M. daubentonii* and *Barbastella barbastellus* have also increased in numbers since the 1980s. The figures show changes in numbers of dominant bat species in the hibernacula under study from between 1957 and 1980 until the present.
This research was supported by the grant of the Ministry of Education, Youth and Sports of the Czech Republic No. MSM0021622416.

GUIDELINES FOR THE RENOVATION OF BUILDINGS HOSTING BAT ROOSTS – AN INTERACTIVE POSTER

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As part of the EU-INTERREG III B-project ‘living space network’ financed by the Arge Alp we aim to produce guidelines for the renovation of buildings hosting roosts of building-dwelling bat species in the Alpine area. These guidelines should give detailed information about protection methods during renovation works and about the effects of changes in roosting conditions (e.g. roost climate, wood preservation, flight paths) of bats at a species level. Supplementing a workshop on the same topic, the interactive poster gives the participants of the 10th EBRS the possibility to share their knowledge. At the poster we present leaflets with short drafts of species-specific guidelines. These first drafts of the guidelines can be confirmed, rejected or amended by the participants based on their own experience and knowledge. The processed sheets should then be returned to another box at the poster. After the EBRS we will update the guidelines with the input from the participants, which will allow us to include as much ‘know how’ as is available on this topic. Subsequently, the final version of the guidelines will be handed out among the contributors to promote successful renovation of buildings hosting bat roosts in Europe.

INTERSPECIFIC VARIATION IN THE ECOLOGY OF TENT-ROOSTING BATS IN EASTERN ECUADOR

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Twenty-three species of bats are known to roost in tents constructed from modified plant parts. While previous studies have documented substantial variation in the architecture of tents, it is not known to what extent this variation represents behavioural differences among bat species. For example, regional differences in the availability of plant species may influence tent architecture, precluding comparisons between bat species observed at different sites. This study examined architectural variation among six sympatric species of tent-roosting bats in eastern Ecuador. Roosts were assessed with respect to architecture, plant species, spatial positioning, habitat association and seasonality of construction. To detect interspecific differences, tents of individual bat species were compared by multivariate discriminant analysis. Two species, *Artibeus anderseni* and *Vampyressa bidens* each roosted in tents that were architecturally different from those of other species, and roosts of *Mesophylla macconnelli* and *A. gnomus* overlapped only to a minor degree. Conversely, roosts of *Rhinophylla pumilio* and *Vampyressa thyone* were nearly indistinguishable from one another although they differed significantly in mean values for several parameters. These results indicate that some architectural variation in tents reflects behavioural differences in the species responsible for their construction. However, significant overlap in tent architecture exists among species, which may be partially attributed to sequential use of roosts by multiple bat species.

DEVELOPMENT OF A CAR-BASED BAT MONITORING PROTOCOL FOR THE REPUBLIC OF IRELAND 2003-2004

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At present in the Republic of Ireland, there is little available bat population trend data. The aim of this monitoring strategy is to collect sufficient data to allow objectively and cost effectively early recognition of ‘Red’ Alert, and if possible, ‘Amber’ Alert declines in certain Irish bat species’ populations. A car-based monitoring strategy was

devised in 2003 by the Bat Conservation Trust, U.K., with funding from the Heritage Council and National Parks and Wildlife Service, and pilot surveys were carried out in 2003 and 2004. Surveyors gathered data using time expansion bat detectors clamped to the window of cars that were driven within 30 km squares. Bat echolocation calls were recorded onto minidiscs and species were identified post-survey by sonographic analysis. A simulation approach was used to assess the statistical power of the method to determine which species could be monitored and whether 'Amber' and 'Red' Alert targets could be met. Additional examinations of bat activity and distribution were carried out. The most commonly encountered species were (in decreasing order) common pipistrelle, *Pipistrellus pipistrellus*, soprano pipistrelle, *P. pygmaeus*, and Leisler's bat, *Nyctalus leisleri*. Although the data collected is limited to roadside populations, power analysis demonstrated that 'Red' Alert targets for common pipistrelle, soprano pipistrelle and Leisler's bat could be met within 15 years monitoring if ten 30 km squares are surveyed twice annually. If 15 squares are surveyed twice annually, 'Amber' alert targets can be met for common pipistrelle within 20 years of monitoring. Power analysis could not be carried out on *Myotis* bats because the encounter rate was too low.

CREATING ALTERNATIVES FOR BAT ROOSTS IN LARGE BUILDINGS AND UNDERGROUND GALLERIES

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Bat boxes have been widely used to replace destroyed roosts in houses and trees. However, they are unsuitable alternative roosts for many European bat species. We recently had to design artificial roosts to compensate for the destruction of roosts in underground galleries and in a 15-storey building that harboured such species. We will present the criteria used to design the new roosts and the bat's reaction to them. The underground galleries harboured several species of cave-dwelling bats (*Miniopterus schreibersii, Myotis myotis, Rhinolophus mehelyi, R. ferrumequinum,* and *R. hipposideros*) and were replaced by two artificial galleries. The oldest of these is now used by large numbers of bats, including all the species present in the original roost. *M. myotis* is now breeding there. The building to be destroyed harbours a large number of *Tadarida teniotis* and some *Eptesicus serotinus* and *Pipistrellus pygmaeus*, behind some of its many concrete plates. Prior to the destruction of the building the site selection and the thermal characteristics of the used plates were monitored to help in designing a new artificial roost. Using the results of this monitoring program a 4-storey replacement roost has now been built. So far only *E. serotinus* has been observed in the new roost, but its success can only be evaluated after the destruction of the old roost that it is supposed to replace. Using the experience gained with these cases we make considerations about the design and follow up of large replacement bat roosts.

THE HISTORY OF THE BAT FAUNA (CHIROPTERA, VESPERTILIONIDAE) OF NORTHWEST ALTAI IN THE PLEISTOCENE AND HOLOCENE (FROM MATERIAL FROM THE DENISOVA CAVE)

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The landscape and climatic changes identified in northwest Altai at the end of the Middle Pleistocene were accompanied by the reconstruction of the mammal community and in the bat fauna in particular. In the Upper Pleistocene the bat community of the Denisova cave consisted of *Myotis blythii, M. daubentonii, M. brandtii,*

M. dasycneme, M. ikonnikovii, Plecotus aff. *auritus, Eptesicus* cf. *nilssonii,* and *Murina leucogaster. P.* aff. *auritus*, *E.* cf. *nilssonii* and *M. dasycneme* were the most abundant species, while the small-sized species of *Myotis* were the rarest. From the Upper Pleistocene until the Holocene the percentage of *Myotis blythii* among the bat community steadily increased. This data, relating to a species that is associated with open landscapes, together with palynological data, confirm that during that period the area of open landscapes was expanding and the forest area was decreasing. From the time that human beings began to exploit the Denisova cave in the Upper Pleistocene the populations of most bat species decreased because of the smoke the human fires were producing. Strong evidence suggests that Paleolithic man occupied the cave only in the winter period, because our data shows *M. blythii* maintaining a summer maternity colony and continuing to grow in number (and so it could successfully increase in summer). The contemporary cave bat community settling in the basin of the Anyi river (northwest Altai) consists of *Myotis daubentonii*, *M. brandtii, M. dasycneme*, *M. frater*, *M. ikonnikovii*, *P. auritus*, *E. nilssonii*, and *Murina leucogaster,* and does not include *M. blythii*. Although *Myotis blythii* occurred in the Lower Holocene, it was decreasing in number, most probably because by that time the open landscape areas were decreasing. From the Holocene until now, small-sized species of *Myotis*, such as *M. daubentonii* and *M. brandtii*, are the most numerous and common species. So the present-day bat community represents the taiga type.

NON-RANDOM BREEDING BEHAVIOUR IN FEMALE HORSESHOE BATS

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Female greater horseshoe bats, *Rhinolophus ferrumequinum*, are strongly philopatric and form maternity colonies each summer to give birth and raise single offspring. In the autumn and spring, females visit males in territory sites distributed throughout the area, and mating occurs. We screened 455 bats, sampled at our study population between 1993 and 2002, at 19 microsatellite loci. We assigned paternity to 240 offspring, and resolved reproductive profiles of all sampled males. An analysis of long-term breeding partnerships showed that most females repeated breeding with the same male across years, leading to a high number of full-siblings in the population. In addition, related females shared mating partners more than expected by chance. Despite the coincidence of these mating patterns, we detected no associated increase in inbreeding. We discuss how these results may have implications for the evolution of kin-selected behaviours and coloniality.

MONITORING OF BATS IN BAVARIA

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Since 1985 populations of bats have been monitored in Bavaria. Monitoring of summer roosts includes 270 colonies of the attic-dwelling *Rhinolophus hipposideros* and *R. ferrumequinum, Myotis myotis* and *M. emarginatus.* These species show increasing populations. However, numbers of *M. myotis* stagnate since the mid-1990s, which is possibly due to habitat changes. *M. myotis* furthermore shows great differences in population development between natural regions, which is probably correlated with available feeding habitats. Monitoring of 130 underground winter roosts provides significant data for *M. myotis, M. daubentonii, M. nattereri, M. mystacinus/brandtii, Plecotus auritus* and *Barbastella barbastellus.* The numbers of hibernating individuals of these species are increasing or were at least stable during the last two decades. Possible causes for the increasing populations are the reduced

environmental burden with chlorinated hydrocarbons, which was assumed to be one of the main threats for bats between 1950 and 1980, the positive impacts of climate change (e. g. warmer summers reduce juvenile mortality), and not least the Bavarian species protection programme for bats: the regular visits to the nurseries and main winter roosts give information about planned renovations of buildings and possible disturbances of roosts and allows the planned implementation of protection measures. Therefore poisoning due to timber treatment in nurseries, and the disturbance of summer colonies and wintering roosts no longer play a significant role as a threat to bat populations in Bavaria.

SPECIES-SPECIFICITY AND INDIVIDUAL VARIATION IN THE SONG OF MALE NATHUSIUS' PIPISTRELLES, *PIPISTRELLUS NATHUSII*

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Sequences of the advertisement calls produced by male Nathusius' pipistrelles, *Pipistrellus nathusii,* during the autumn mating period were recorded from individuals at two separate sites in Antrim, Northern Ireland in August 2004. Several male roosts were found at these sites in close proximity to a single maternity roost each containing approximately 200 adult females and their young. Analysis of measured parameters of four identified call types revealed that there were significant differences in call structure between sites and between individuals. Playback experiments, performed outside the adult female and juvenile roost sites, consisted of experimental advertisement call sequences of *P. nathusii, P. pygmaeus* and *P. pipistrellus* and control sound recorded without bats present (silence). Response was measured by simultaneously recording ultrasound during playbacks and counting the number of echolocation pulses above a predetermined threshold, which were then identified as those of *P. nathusii*. Significantly greater numbers of *P. nathusii* echolocation pulses were recorded during playback of male *P. nathusii* advertisement calls than during playback of congeners' advertisement calls and control sound. The number echolocation pulses recorded were similar during playback of *P. pipistrellus* and *P. pygmaeus* advertisement calls and silence. We suggest that, due to call complexity, male *P. nathusii* advertisement calls should be classified as 'song'. Species-specificity and individual variation suggests that the songs of male *P. nathusii* have the potential to play a role in mate attraction and mate assessment.

PATTERNS OF ROOST SELECTION AND ROOST SWITCHING IN TREE-DWELLING BARBASTELLES, *BARBASTELLA BARBASTELLUS*

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We studied roost selection and roost switching behaviour in a tree-dwelling population of barbastelle bats, *Barbastella barbastellus*, in a beech forest of central Italy. We located 65 tree roosts by radio-tracking. Unmanaged woodland was favoured for roosting; woodland subject to limited logging was used in proportion to availability, and areas where open woodland and pasture occurred were avoided. Tree selection depended on tree condition (dead beech trees were preferred) and height (roost trees were taller than random ones). Roost cavities selected were mainly beneath loose bark, at a greater height above ground and facing south more frequently than a random sample of cavities. Roost switching was common to both sexes and did not depend upon group size. We observed both individual and group switching, the latter often involving the abandonment of a roost tree on a single night. Bats almost never crossed mountain ridges to use roosts located beyond them, possibly because ridges are regarded as boundaries delimiting main roosting areas. Switching rate was lowest in the middle of lactation, probably to minimise problems related to the transportation of non-volant youngsters by their mothers. To ensure the persistence of a *B. barbastellus* population in a certain area, it is necessary to protect a high number of trees and large forest

patches. If further work confirms the existence of adjoining forest patches representing separate roosting areas, conservation plans will have to locate such areas and treat them as independent management units.

GENETIC STRUCTURE AND GENE FLOW AMONG POPULATIONS OF THE AZOREAN BAT BASED ON MICROSATELLITE MARKERS

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The Azores archipelago in the Atlantic Ocean is located about 1,500 km west of mainland Portugal and comprises nine islands. Due to its isolation, few terrestrial vertebrates were able to colonise successfully this archipelago. One exception is the endemic Azorean bat, *Nyctalus azoreum*, which is present on seven islands. It is thought to have recently speciated from a continental ancestor related to the Leisler's bat, *Nyctalus leisleri*. Previous estimates of population structure assessed by sequencing a highly variable mitochondrial marker revealed that Azorean bats were highly structured between the Central and Eastern group of islands, and suggested either current or historical female migrations limited to neighbouring islands. We address here the same questions by using biparentally inherited markers (microsatellites) to estimate more precisely the likelihood of inter-island gene flow. We genotyped 280 individuals from 14 populations sampled in six islands. Thirty *N. leisleri* from a population in Portugal were also analyzed to provide a baseline comparison of a mainland relative. Six pairs of primers designed originally to amplify microsatellite loci in *N. noctula*, were successfully tested in *N. azoreum* and *N. leisleri* and revealed high levels of allelic diversity (5 to 14 alleles per locus) and strong population structure. The results of this study based on nuclear genes will be combined with previous estimates of female gene flow to contribute to the optimization of the protection of this endangered species.

DIET AND PREY SELECTION IN SIMILAR SYMPATRIC *RHINOLOPHUS MEHELYI* AND *R. EURYALE:* DO THEY COMPETE IN WHAT THEY EAT?

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We determined the diet of sympatric *Rhinolophus mehelyi* and *R. euryale* by the analysis of droppings collected in a mixed nursery colony in June 2003. Arthropod fragments were identified and relative volume of each category was estimated. We identified 5 categories in *R. mehelyi*, moths (Lepidoptera), green lacewings (Chrysopidae), ant-lions (Myrmeleonidae), Tipulidae and Brachycera. The diet of *R. euryale* consisted in 4 categories, moths, green lacewings, ant-lions, and beetles (Scarabaeidae). The most consumed prey of the two bats was moths (≈ 85%). Comparing diet composition with prey frequency sampled around the colony, we found that moths, green lacewings, ant-lions and Tipulidae were positively selected in *R. mehelyi*, whereas in *R. euryale* moths and green lacewings were positively selected and ant-lions and beetles were consumed opportunistically. The other categories were underrepresented in the diet of both species. Although prey distribution in the diet was significantly different between the species, moths, green lacewings, and ant-lions composed the bulk of the diet (> 90%) in both species. Trophic niche breadth was not different between bats, and intraspecific trophic niche overlap was significantly higher for *R. euryale* (0.86) than for *R. mehelyi* (0.783). Interspecific trophic niche overlap (0.779) was very high and very close to *R. mehelyi*'s intraspecific value. These results corroborate a low trophic niche divergence and a possible competition between the two bats and suggest that their coexistence in sympatry should rely on spatial partition of feeding grounds.

FROM RADIO-TRACKING DATA OF INDIVIDUAL BATS TO FORAGING AREAS OF A BAT COLONY: EXTRAPOLATION USING ECOLOGICAL NICHE FACTOR ANALYSIS (ENFA)

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Radio-tracking is a powerful method to collect information on spatial behaviour and habitat use of individuals and is widely used in bat research. Data collected by short radio-tracking sessions represent a temporal fragment of the seasonal habitat use of an individual bat. This restriction is of special importance in applied ecological studies, especially when related to environmental planning (i.e. construction of roads). Often, the objectives of such studies are general statements about the spatial habitat use of a bat colony or the entire population in the area concerned. But how can we generalise observations from radio-tracking studies of single individuals to the whole species in a certain area? We suggest a new approach applying the Ecological Niche Factor Analysis (ENFA) by using single foraging locations as presence data. It allows us to extrapolate spatially explicit habitat suitability maps for a whole colony or region. We applied this procedure to several data sets of the endangered lesser horseshoe bat *Rhinolophus hipposideros* from two alpine regions of Switzerland and a lowland area in Germany. Our results show that extrapolation of clumped, individual radio-tracking points through environmental niche parameters yields promising predictions of the habitat use for the whole colony. Based on this method we are able to designate the most important foraging areas and landscape characteristics for commuting flights. The resulting potential utilisation maps allow the identification of conflict zones between animal habitats and planned constructions as well as to spot suitable areas that remain spatially isolated. Therefore this analysis allows both the derivation of ecological knowledge about the spatial habitat use and the ability to suggest concrete management recommendations.

OBSERVATIONS ON *NYCTALUS NOCTULA* BREEDING IN ITALY

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The noctule bat, *Nyctalus noctula* is a widespread species in Europe, where it is considered a typical northern breeder that migrates to mate and to winter in Mediterranean habitats. Reproduction in southern countries is recorded for Spain and for Italy where the first colony was sighted along the Romagna coast twelve years ago. Actually other colonies are know for Friuli and Veneto (Northern Italy) and a newborn young was sent to a recovery centre from the surroundings of Firenze. The distribution of reproductive colonies in southern Europe is probably underestimated, but few data are still available. The population in Cervia, along the Romagna Adriatic coast, was checked to understand distribution of roosts, type and volume of hollows in trees, and phenology. All the tree lines in the village were checked at dusk to listen for the bats preparing to emerge. In addition, infrared counts of swarming bats and bat detectors were also used. A total of 2,200 trees were checked and at least 22 of them were identified as permanent or temporary noctule roosts. The whole group was calculated to reach 500 individuals. In a single tree the maximum count was 243. Phenology is quite complex with female groups arriving in mid-May and reaching the main trees cavities where in June they give birth and where the young grow until July. The groups are concentrated in a few trees, with some solitary males in small trees in the surroundings. In August small groups of females use more trees including some with "poor" cavities, and in September the males call for the females. From October the females migrate. We found in March some males roosting in tree hollows. The management of older trees and the conservation of branches and trunks with large hollows are critical for the noctule and a strong effort will consider the conservation needs of the species.

BAT USE OF MINE TUNNELS AS KARST ENVIRONMENT SUBSTITUTE

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We explored the complex of tunnels of the gypsum mine of Monte Tondo, near Riolo Terme in Italy in different season in year 2003-2005, thanks to the owners of the property, B.P.B. Italy. The quarry is active but the tunnels are not currently in use and extraction is carried out on the other side of the hill by open quarrying. The 13 km of tunnels were used for extraction until 20 year ago and now only a small part of them (around 2 km) are in use for storage or garages. The tunnels were excavated on three different levels and present some connection with natural cavities present in the mountain, as well as some different microenvironment differences of humidity, temperature variation and presence of human disturbance. At least six species use the tunnels: *Rhinolophus ferrumequinum, R. hipposideros, R. euryale* in winter and *Myotis myotis, M. blythii* and *Miniopterus schreibersii* also for reproduction with a mixed colony of around 3,000 specimens. In winter a large group of *M. schreibersii* hibernates at around 6 °C both in areas of the tunnels close to a part used as a garage, and within distinct sound of trucks, and in remote places, in the vicinity of a small group (from 50 to 100 individuals) of Rhinolophids. We suspect that the wintering colony of *M. schreibersii* collects all the individuals of the subregion including from natural karst environments now modified by human activity. The "new" tunnels were colonized shortly after become quiet and bats now use the parts with different microclimate in relation to specific requirements through the year. Thus, an environmentally 'unfriendly' human activity provides a valid roost habitat for important bat species and has become classified as a *special area for conservation* in EU. Suggestions for monitoring and management of the tunnels with such important inhabitants are also currently under study with the help of the property owners and under the umbrella of the local offices for nature conservation.

HABITAT ANALYSIS OF A BAT COMMUNITY TO PRODUCE MANAGEMENT GUIDELINES

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One of the aims of a LIFE project in Onferno was to analyse the bat community and its use of the territory to identify the best management model for a small scale protected area with a large bat community. Phenology and composition of the bat fauna inhabiting a 270 ha. nature reserve in north Italy were studied to learn how ten species (*Rhinolophus euryale*, *R. ferrumequinum*, *R. hipposideros, Myotis blythii*, *M. myotis, M. emarginatus, Hypsugo savii, Pipistrellus kuhlii, Eptesicus serotinus* and *Miniopterus schreibersii)* can share the different microhabitats of its hilly mosaic of wild vegetation, agriculture and small pasture zones and can find special refuges in a cave of more than 700 meters in a gypsum outcrop. In particular, we tracked females fitted with small radio tags (LB-2 Transmitters, Holohil Systems Ltd, Ontario, Canada) of seven *R. euryale*, three *R. ferrumequinum*, four *M. myotis* and nine *M. schreibersii* in order to explore their habitat use. Monitoring was performed in spring, summer and autumn in three sessions of 15 days each. Core areas and home range show great variation between seasons and can vary from 86.45 ha for *R. euryale* in spring to 905.29 ha for *M. schreibersii* in autumn for the home range. Also the habitat use changes with the time of the year. These data can be used to prepare a local action plan to manage the protected area and to improve a wider approach to bat conservation in the area. Also problems arising from different local administrations and the perception of the problem are discussed. For the horseshoe bats considered here the conservation effort of the Natural Reserve can be enough, if rules for agriculture are carefully followed, but to conserve a viable environment for the more than 5,000 miniopterids the plan has to consider 3 different valleys, two provinces and also the state of S. Marino Republic, where part of the group forages at more than 30 km from the cave.

THE DAY AFTER TOMORROW: MONITORING CONSERVATION PRACTISE AFTER THE LIFE PROJECT "PELLEGRINO"

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A monitoring programme started in 2004 in the Bologna province is following the actions initiated by the LIFE Nature Project "Pellegrino 1998-2000". The programme was developed to follow and understand the effects of activities generated to improve bat conservation in 7 SACs located in the hills around Bologna to the Appennine ridge. This project is one of the very few adopted by local administration to check the results of a LIFE project's activities and a pilot experience to improve knowledge about bats in a provincial territory. More than 950 bat boxes, 70 m of bat-boards, a tunnel and 4 attics were checked for bat presence during different seasons. Bat detector surveillance and specific surveys were also conducted in the different environments of the SACs of the area to check bat species and the presence of roosts. The bats identified during the monitoring were *Rhinolophus ferrumequinum, R. hipposideros, Myotis bechsteinii, M. daubentonii, M. emarginatus, M. nattereri, Pipistrellus kuhlii, Pipistrellus pipistrellus, Nyctalus leisleri, Hypsugo savii, Eptesicus serotinus, Barbastella barbastellus* and *Plecotus auritus.* Two colonies of *R. hipposideros* were discovered, as well as a colony of *M. bechsteinii* that occupied a small "open tunnel" in sandy rocks with their newborn young for two weeks before moving to an unknown site. New localities for *B. barbastella* and for small *Myotis* were also added to the fauna of the area. The sites with bat boxes are characterized by woodland of poor biological and forestry quality, and only one *Pipistrellus pipistrellus* was found in around 900 boxes. Only in the mountain forest of Corno alle Scale, where forest is well structured and diversified, the 20 boxes were occupied by pipistrelles and also by *Plecotus austriacus* and *Nyctalus leisleri*, the latter also with reproductive harems in autumn. Other activities to improve local and general public awareness, to identify the location and size of colonies will be presented, as well as the activity of the project that will finish next year.

SIZE VARIABILITY AMONG POPULATIONS OF THE GREATER HORSESHOE BAT, *RHINOLOPHUS FERRUMEQUINUM,* (SCHREBER 1774) IN THE NEAR EAST

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The geographic size variability of *Rhinolophus ferrumequinum* has been much studied in Europe and is quite well known. However, the distribution of *R. ferrumequinum* is much wider, and we know very little about populations of even quite neighbouring areas, such as the Near East. We therefore studied geographic size variability of skull material originating from Azerbaijan, southern Turkey and Syria. We found surprisingly high size differences among bats from these areas. Whereas specimens originating from southern Turkey are a little smaller in size (comparable with the situation in central Europe), specimens originating from the quite near area of the Turkish-Syrian border are the largest in size even compared with bats from the South of the Balkan Peninsula. Specimens originating from the more eastern parts of Syria are smaller again and comparable in size with Balkan populations. Extremely small bats were found among Azerbaijan's specimens. It could be that this more extreme size variability is due to the fact that weather conditions change more rapidly in these areas compared with Europe?

THERMAL ASPECTS OF *MYOTIS MYOTIS* HIBERNATION IN TWO CAVES OF THE MORAVIAN KARST

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During two hibernation periods (November to April]) we carried out research on hibernating *Myotis myotis* (in total 29 visits) in the thermally variable parts of two caves in Moravian Karst (CZ). Hibernating bats were checked

without any disturbance as the temperatures were measured via non-contact Raynger MX2 infrared thermometer. In the Kateřinská cave the influence of outside temperature has been recorded that results in the absence of bats during the first days of the hibernation period. The numbers of bats in the entrance corridor of this cave started to increase about 4 to 6 weeks later than in the Králova cave, where the temperature is more stable. Departure of the majority of the bats from the hibernation site was recorded in the first half of April. The largest recorded groups of bats were 36 (4.4.2003) individuals in the Kateřinská cave, and 56 (26.3.2004) in the Králova cave and were the same during both years. The most frequently occurring clusters were 2 to 5 bats. The recorded range of body temperature in the Kateřinská cave was –0.4 to 5.3 °C (average 2,6) and in the Králová cave it was –0.5 to 5.4 °C (3.2), respectively. In the latter, the body temperature was considerably higher in comparison with the former during both years. There were no records of differences between the body temperature and the temperature of the locations in the caves of hibernating bats, and they were always considerably higher in the beginning of hibernation than later on.

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ATYPICAL BAT BEHAVIOR DUE TO LIGHT SUMMER NIGHTS - USE OF SOUND ANALYSIS IN MAPPING *MYOTIS* SPECIES IN CENTRAL NORWAY

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The bat fauna in the two counties of Central Norway (62° - 65° N) is still insufficiently studied, although bat mapping has been going on since 1995. Seven species have been found until now. Many of these observations are *Myotis* species. Three *Myotis* species are confirmed from the area; *Myotis brandtii, Myotis mystacinus* and *Myotis daubentonii.* Only heterodyne ultrasound detectors have been used in the mapping so far. Although less than 50 individuals of *M. daubentonii* have been found until now, it is suspected that the light summer nights in central Norway discourages the species from hunting in its typical environment close to the water surface. This could lead to fewer observations of the species, especially since most of the local observers do not have much experience in observing *M. daubentonii.* By using time expansion recordings of sound and sound analysis in cases of doubt, a higher percentage of the individuals could be identified to species. This will hopefully reveal whether *M. daubentonii* is a common species in the area. If it is not, most specimens of this genus in the area will probably be *M. brandtii. M. mystacinus* is found in only one place in the two counties. Survey work will be carried out in June and July 2005.

THE AGREEMENT ON THE CONSERVATION OF POPULATIONS OF EUROPEAN BATS (UNEP/EUROBATS)
Developments since the Fourth Session of the Meeting of Parties

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The 4th Session of the Meeting of the Parties (MoP4), which was held in Sofia, Bulgaria (September 2003), adopted a lot of important resolutions. Many of them have led to the reconstitution or establishment of new Intersessional Working Groups (IWGs) during the 9th Meeting of the Advisory Committee (AC9) in Vilnius, Lithuania (May 2004), where they agreed on their work plans for the next triennium. All relevant Meeting documents are available on our website (for MoP4 Resolutions see Annexes of MoP4 Record; the IWGs and their work programmes are listed in Annexes 2 and 3 of AC9 Record) on www.eurobats.org under the link "Official documents" / "Meeting reports". The most important topics are summarised here below.

<u>Data compilation on important underground habitats for bats and Guidelines for their protection and management</u>

The Parties recognised the importance of underground habitats to many species of bats and their threat by a wide variety of anthropogenic factors. Therefore MoP4 decided that Parties who have not yet done so should identify important underground habitats for bats and ensure their full protection by law as well as physical protection against unauthorised entry.

It was agreed during AC9 to close the list of important underground sites on 1 January 2005 but to review it in 5 years time to assess new information.

Draft Guidelines for the Conservation and Management of Underground Habitats for Bats already exist (in English) and it is planned to publish these Guidelines as the first issue of a series of EUROBATS publications. The EUROBATS Secretariat is currently working on the translations into German, French and Bulgarian and hopes to be able to provide the publications in the different languages before the next AC Meeting.

Bat Conservation and Sustainable Forest Management

MoP4 recognised the importance of forests for bats and decided *i.a.* that Parties should identify key areas and key elements for bats in forests, which should be protected, restored and enhanced. Forestry should be combined with bat conservation, and research should be promoted on the relationship between bat communities and forest types as well as the impact of forestry. Existing information on bat conservation in forests should be collated and provided also in other languages. A respective initiative is under way at the moment: a German leaflet on bats in forests provided to other European countries was already translated and published by Romania. The Czech Republic and Serbia & Montenegro are about to do so soon, and Ireland will incorporate the leaflet information into a web-based information sheet for foresters. Bulgaria, Croatia, Estonia and FYR Macedonia have also expressed their interest in this initiative.

Guidelines for the Use of Remedial Timber Treatment

MoP4 decided that Parties should endeavour to get data on potential impact of timber treatment products on bat populations, to share this information with other countries and to bring it to the attention of the users of such products. New pesticides should be assessed for their toxicity to bats and the use of any that are likely to be a significant hazard should not be permitted.

Guidelines for the Issue of Permits for the Capture and Study of Captured Wild Bats

All activities related to bat capture, ringing and marking should require licences issued for a fixed (renewable) term. The license should be issued by designated nature conservation authorities (if necessary after consultation with a body that is competent in the study of bats and their conservation) upon a written application outlining the reasons for the proposed project. Licence holders should demonstrate competence in the activities to be licensed in order to be able to keep standards set by the licensing authority. The licence should identify permitted techniques and equipment, incorporate the obligation for a reporting procedure, and may restrict the carrying out of certain activities. Parties should not provide support for projects involving capture or marking in Range States that do not have policies that comply with these guidelines.

The guidelines have been adopted at MoP4, but a possible review is scheduled for AC11 in 2006.

Wind Turbines and Bat Populations

MoP4 requested the Advisory Committee to assess the evidence of the impacts of wind turbines on bat populations and, if appropriate, to develop guidelines for such assessments. Until this task is completed, the Parties and Range States should take full account of the precautionary principle in the development of wind turbine plants. Furthermore, attention should be paid to bats in planning processes relating to the positioning of wind turbines, especially along migration routes and in areas of particular value to bat populations. Parties and Non-Party Range States are encouraged to initiate and support further investigations as well as research on the impact of wind turbines on bats. The first steps of the newly established Intersessional Working Group on bats and wind turbines are the collection and analysis of existing data and the evaluation of its own questionnaire, which will be circulated to all Range States before the next Advisory Committee Meeting in 2005. If appropriate, guidelines will be drafted afterwards.

Amendment of the Annex to the Agreement

At MoP4, the Parties decided to amend the Annex, which had been incorporated to the Agreement during MoP3 in 2000 in Bristol, United Kingdom, by including several newly described European bat species. The Annex was changed according to the rules laid down by the International Commission on Zoological Nomenclature. A small Advisory Panel of taxonomic specialists will continue to review potential changes to the Annex in future.

Implementation of the Bat Conservation and Management Plan (BCMP) (2003-2006)

MoP4 adopted the new BCMP, which sets the priorities for bat conservation for the period 2003 – 2006. Beside many topics for which separate resolutions were adopted (underground sites, forest practices etc., see above), it was *i.a.* decided to review the impact of anti-parasitic drugs for livestock on bat populations, to produce guidelines on monitoring methodologies as well as on the consideration of bats' requirements in all cases of land management and development. The geographical scope of the Agreement is another subject of the BCMP; it incorporates further data collection on bat migration and the conservation of migratory species.

Beside the resolutions dedicated to bat conservation, MoP4 also adopted administrative ones, which lead to important progress for the EUROBATS Secretariat:

MoP4 adopted further resolutions on "Contributions to the CBD/CMS Joint Work Programme"; "Recognising the Important Role of NGOs in Bat Conservation" and "Priority Species for Autecological Studies".

WHAT CENTRAL HEATING DOES FOR BATS – THE EFFECT ON OCCUPANCY OF ARTIFICIAL HEATING IN BAT HOUSES

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A heated bat house has been developed to provide alternative nursery roosts for colonies, especially of pipistrelle bats, excluded from buildings in cool climates. An integral heating system has been incorporated into a basic BCI bat house design that can be mounted on a building wall or a pole. The roosting chamber is divided into crevices physically separated from the electric coil heaters. Temperature is controlled by a solid state circuit with its sensor embedded in the roosting chamber. Power is supplied by the mains system of the host building or by a lead-acid battery charged by a solar panel, and the power demand is less than that of a 60W bulb. Temperature inside a pipistrelle roost in a building was monitored using data loggers, and the heating system designed to mimic it. In field trials, the bat houses maintained a temperature consistently 12-14 °C above ambient to a pre-set level of 27-28 °C, above which the heaters switched off. At ambient temperatures above 12 °C, the pre-set minimum roost temperature was maintained, while in strong sunlight around 40 °C was recorded for short periods, due to radiant heating. At sites where pipistrelles had been excluded from buildings, two of three heated bat houses were occupied for the first time within three months of installation, while none of the unheated control houses was ever occupied. In their second summer, the same two bat houses were occupied from May onwards by nursery colonies of *Pipistrellus pygmaeus,* and young were reared in them. Field trials are ongoing at six sites in Scotland.

THE NATIONAL BAT MONITORING PROGRAMME IN ROMANIA

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In this paper we present the background and the achievements of the National Bat Monitoring Programme in Romania started in 2002. This work is achieved by working out the monitoring methods and by volunteer involvement and education. In 2003 the Strategy of National Bat Monitoring was prepared concerning the summer and winter underground habitats of the priority species: *Rhinolophus ferrumequinum, R. hipposideros, Myotis myotis/blythii, Miniopterus schreibersii, Myotis daubentonii, Eptesicus serotinus, Pipistrellus pipistrellus/pygmaeus, Nyctalus noctula* and the monitoring methods in the field for flying bats. The method of underground habitats monitoring includes checking twice in the winter period (December- February) and twice in summer (May-July). During 3 years of volunteer involvement 35 presentations were given to more than 400 participants of different organizations and there is permanent communication with 75 key persons, 20 of whom are involved directly in the monitoring. We expect to obtain results on population trends in 10 years by implementing the monitoring programme at a national level.

DISTRIBUTION OF *MINIOPTERUS SCHREIBERSII* IN ROMANIA

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In this paper we present the data collected by the authors between 1996 and 2005 about the distribution of *Miniopterus schreibersii* in Romania, and compare it with data from literature. The check of winter and summer roosts, mist-netting and detecting bats with ultrasound detectors were used as methods. During the survey we found *Miniopterus schreibersii* in 20 underground habitats. The biggest hibernation colony was formed by 33 000 individuals. The distribution of the species is presented on a UTM grid map. The species is very sensitive to disturbance and it is included in the National Bat Monitoring System.

SKULL MORPHOLOGY OF SIBLING BAT SPECIES *PIPISTRELLUS PIPISTRELLUS* AND *P. PYGMAEUS* – THE 3D GEOMETRIC MORPHOMETRICS APPROACH

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We investigated differences in skull morphology of two sibling species using the geometric morphometrics method. This method, based on homologous landmark measurements, has certain advantages over traditional morphometric tools. It enables independent description of size and shape, anchors explanations for those differences to specific regions of organisms and recovers geometric properties of the skull shape in three-dimensional space, thus avoiding information loss that occurs when using traditional morphometrics. Fifteen specimens of both species were examined. We collected 66 landmarks on the ventral side of the skull, 23 on the dorsal side and 34 on the lateral external side of both left and right mandible. We especially focused on dentary apparatus (more than 50 of the landmarks depicting tooth-rows) with reference to differences in diet of these species. All examined skull parts proved to be larger in *P. pipistrellus* but not all the differences were statistically significant. The biggest difference (statistically significant) was observed in mandible size. Shape differences were analyzed by Principal Component Analysis of Procrustes superimposed landmarks, and illustrated as transformation grids in the relative warp space. The maxillary part of the skull of *P. pipistrellus* was relatively wider than that of *P. pygmaeus*. Significant differences were also observed in the mandibular ramus. Hence differences in skull morphology were related to dietary differences between the two species, because *P. pipistrellus* feeds on larger prey than *P. pygmaeus*.

USING GENETICS IN THE STUDY OF BATS

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Molecular biology has revolutionised our understanding of the natural world. Although the direct implications of molecular research are wide reaching and multidisciplinary, the terminology and methods can confuse and alienate the 'genetic' illiterate. This talk will be a 'crash-course' in molecular terminology and methods. Three major molecular markers (microsatellites, mitochondrial DNA, nuclear DNA) will be introduced and described. Their role in recent evolutionary and ecological studies of bats will be detailed and reviewed using examples. The suitability of each molecular marker for a particular question in bat research will be assessed.

IBBAT TEMPERATURE LOGGERS – A NEW OPPORTUNITY FOR STUDYING BODY TEMPERATURE, AROUSAL FREQUENCY AND ACTIVITY OF BATS DURING HIBERNATION UNDER NATURAL CONDITIONS WITHOUT HUMAN DISTURBANCE

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The sensitivity of hibernating bats to tactile human disturbance makes it difficult to study the depth and duration of torpor during the hibernation period without introducing observational bias. Here we present a new miniature data-logger based on the iButton Thermochron technology (the iBBat by Alpha Mach, Mont St. Hilaire, Québec, Canada) that allows the measurement and storage of body temperature over the entire winter, thus avoiding observational bias. The iBBat has a mass of approximately 0.8 g that allows its application in the study of hibernating species as small as roughly 10.0 g. The iBBat offers a memory capacity of 8,192 time-labelled data entries with 0.5 °C resolution or 4,096 entries with 0.125 °C resolution. The iBBat interfaces with a computer via a relatively user-

friendly software, allowing it to be programmed for immediate or delayed start-up and temperature measurement at a user-defined interval. The time drift during the tests preceding the entire experiment was small, and did not exceed 6 seconds per 24 hours. Using iBBAT data-loggers opened up an opportunity to estimate the most important parameters of natural hibernation i.e. temperature preferences, arousal frequency and the length of torpor and euthermy periods. Preliminary field studies were performed in the winter of 2004-2005 simultaneously in Québec (Windsor Mine) and in Poland (Sowia Dolina Mine), areas where relatively severe winter temperatures preclude the possibility of winter-feeding. Choosing ecologically similar species (little brown bat, *Myotis lucifugus*, in Canada, and Daubenton's bat, *Myotis daubentonii*, in Poland) made it possible to compare their hibernation strategies. We present some preliminary observations on the depth and duration of torpor bouts for both species.

THE VARIATION IN THE DISTRIBUTION OF BATS ON THE COAST AND IN THE ARCHIPELAGO OF SOUTH-WEST FINLAND

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Relatively little research has been conducted in Finland and globally on the ecology and distribution of bats. For example, the migratory behaviour of many species and their relation to coastal environment and archipelago are subjects that have previously been unexplored in Finland. This basic information nevertheless has an important role in the planning of the protection of rare and endangered species. This report includes an examination of the variation in bat populations in three archipelago zones and on the continental coast together within nine areas belonging to the Natura 2000 network. By using an ultrasound detector and the line-transect method, bats were observed on eight different dates in the research areas in the spring (period I, 7 May -1 June), summer (II, 8 June - 6 July) and autumn (III, 12 August-21 September) of 2002. On the basis of the observations, abundance indices (observations/km) were calculated for all observed species. The variation in bat numbers in relation to archipelago zones and seasons was analysed with a statistical model. The analysis also included a comparison between different habitats at different research dates, which was conducted with the help of the abundance indices. The results include 1,204 bat observations: 666 northern bats, *Eptesicus nilssonii,* 306 whiskered/Brandt's bats, *Myotis mystacinus/brandtii,* 132 Daubenton's bats, *Myotis daubentonii,* three brown long-eared bats, *Plecotus auritus,* one parti-coloured bat, *Vespertilio murinus,* and 96 bats of unidentified species. The bat density was considerably lower in the outer archipelago than in the other archipelago zones. The abundance indices of both the total observations and the northern bats were highest on the mainland and the numbers of observations were considerably higher in spring than in summer and autumn. The three most popular habitats in spring (period I) were shores, wetlands and cliffs/quarries, while in summer (period II) the three habitats were cliffs/quarries, spruce woods and built areas/parks. In autumn (period III) the habitats were ranked wetlands, cliffs/quarries and built areas/parks. During every period the smallest number of bats was observed in meadows/pastures and fields. The bat density is highest on the continental coast and lowest in the outer archipelago. Large numbers of bats can be observed in the most important mainland feeding areas in spring. In autumn, more than average numbers of bats can be observed in the outer archipelago zone, which may result from three factors. Firstly, there is more food available in the outer archipelago, which may increase the number of bats. Secondly, it may be that the bats move southward, closer to their possible wintering quarters in the archipelago. In case of northern bats, it may be that part of the Finnish population even move south of Finland to hibernate. Lastly, it can be that young individuals are dispersing to new territories.

CONVERGENCE IN ECHOLOCATION SYSTEMS

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Echolocation as a form of obstacle detection is surprisingly widespread in the animal kingdom. However, only bats and dolphins are known to use it with any degree of proficiency. All microchiropteran bats use echolocation, while only one genus of megachiropteran bats does. In general, airborne systems use long-duration signals that are non-optimal for target ranging as a consequence of their imprecise time of arrival. Cetaceans on the other hand use short duration impulsive click signals. Here we describe the results of the latest experiments on an airborne impulse echolocation system as used by the megachiropteran bat *Rousettus aegyptiacus*. The structure of the click signals are very similar to Gabor functions, which have the minimum bandwidth for any given duration, and are also very similar to those used by dolphins. In addition, *R. aegyptiacus* appears to use ear movements as a possible mechanism for gain control during echolocation, and shows modification of call rate during obstacle detection, as well as adaptation with familiarity to its acoustic environment. These results will be discussed with reference to the convergence of echolocation systems across a number of taxa.

INVESTIGATIONS IN DISEASES AND CAUSES OF DEATH IN NATIVE BAT SPECIES FROM GERMANY

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The great majority of bat research concentrates upon biological aspects like ecology, behaviour or physiology. On the other hand, information regarding diseases within this animal group is rather limited. If diseases are at all the subject of study they mostly concern (ecto-) parasitic infections or rabies. Additionally, of these reports, only a few originate from the European continent. We have started a study to investigate the occurrence of diseases in native bat species from Germany. So far over 50 freshly deceased or moribund individual bats of 11 different species have been submitted to IZW by people involved with bat protection projects. As soon as possible after retrieval, dead animals were deep-frozen at either –20 °C or –80 °C and kept frozen until necropsy. All animals were patho-histologically examined. If the condition of the carcasses was considered to be still fresh enough, bacteriological investigations were performed directly alongside the post mortem examination. The first results of these investigations will be presented, aiming to give more insight into the actual occurrence of diseases and their infectious agents, to increase the awareness of diseases known from among bat species, and to encourage scientists involved in bat research to support our project in future.

CONSERVATION OF *MINIOPTERUS SCHREIBERSII* AND *RHINOLOPHUS EURYALE* NURSERY IN THE VETERNICA CAVE

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Miniopterus schreibersii and *Rhinolophus euryale* are considered as priority species for autecological studies according to UNEP/EUROBATS. In Croatia all bats species are legally protected. In the Croatian Red List (2004) *M. schreibersii* is in the EN category and *R. euryale* in the VU category. Research on both species started in 2003 in the Veternica Cave near the town of Zagreb, the capital of Croatia. The nursery of both species with ca 500 individuals uses the unprotected, warmest part of this cave. Although the cave is under the authority of Medvednica Nature Park the bats are often disturbed since it is very close to the capital and a guided tour is encouraged. The path leading to one of the popular tourist spots passes by the cave and bats may easily be disturbed. A data-logger measuring the temperature and relative humidity every 5 minutes is located in the part used by bats. The bats usually start to use the cave in June and depending on the weather they may stay there until late October. In the year 2003 no young were recorded in the cave, but there were young in the following year. Possible reasons for this may include extensive disturbance by visitors. In this work, we present data on the current status of both species in Croatia, microclimate measurements, wing design of traced individuals, and a proposal for using grills that would restrict disturbance of bats by visitors for the protection of that part of the cave.

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Book Review

A Bat Man in the Tropics: Chasing El Duende.
Theodore H. Fleming. 2003. University of California Press. Berkeley, CA. Pp. xxi + 311.
ISBN 0-520-23606-8

I have known Dr. Fleming (Ted) for many years, but unfortunately, I have never had the pleasure of working with him in the field. I have heard many of his presentations at numerous conferences and read much of his work in the professional literature, as well as his great book on *Carollia*. Ted and I have had many pleasant conversations about a variety of topics and reading this book has introduced me to a multitude of previously unknown facets of his career and personality. To read *A Bat Man in the Tropics* is to know him even better.

Ted defines "el duende" as a hobgoblin or ghost, much like the common characterization of bats or other poorly understood creatures. He also uses "el duende" as a metaphor for the process of scientific inquiry, or perhaps other worthwhile but often elusive goals or ideals, perhaps as in the sense of "Jason and the golden fleece." This is an enjoyable and satisfying journey with him as he pursues his "el duende."

It appears that this book is not intended as a definitive scientific treatise but rather a narrative of how one gets to the point of writing scientific publications. Most biological findings that are alluded to have been published elsewhere by Dr. Fleming and his colleagues, and the book is essentially a story about all the great and small details that are involved in collecting that kind of information. Scientific papers do not just suddenly appear in the literature but do so only after much original thinking and only after much hard work. This narrative is replete with examples of that hard work and the sometimes difficult conditions encountered in remote field locations.

Research involves a wealth of technical methods and observations that often are described in great detail in the final published papers, but there is also a wonderfully human element that most editors insist on removing from any manuscript. Workers do get rained on, boiled in the hot deserts, shot at, or chased by militia or even bandits. They fall dead-tired into a damp and lumpy sleeping bag and awake to a scanty breakfast of stale cereal with cold coffee. Assistants mix up the data, associates become tired and irritable, and even the boss gets a little weird on occasion. Equipment doesn't always work the way the designer promised, and field vehicles break down or occasionally are stolen. The one bottle of fixative that you absolutely need is broken, and the gadget that you simply must have is sitting in the lab thousands of miles away. Ted's book recounts with great good humor many such examples that will cause experienced field workers to recall similar things that happened to them in their version of Timbuktu last year. Ted gives a masterful description of the woes associated with fieldwork, and many readers will likely say, "Been there; done that!"

Ted constantly reminds the reader that gifted individuals from the past frequently laid the groundwork for many of his ideas, and he develops this foundation throughout the his narrative. Each new chapter or research direction is presented so that the reader might appreciate the work done by others that brought us to the current point. Some of these retrospections are very informative and fascinating, while others are a bit short and leave the reader hoping for more. This aspect of the book is quite elegant.

There is an index of names mentioned in this story that includes over 180 individuals, most of whom can be included in a "who's who" of bat biologists past and present (excluding Anastasio Somoza and several others). Most readers, like this author, will recognize many names as friends and colleagues, and Ted was indeed fortunate to have been in such great company.

Although there is not a gazetteer listing each place where these events took place, many of the site descriptions allow the reader to form vivid images of the deserts of the Southwest and the tropics. His descriptions of the flora and fauna are very detailed, and the great respect and appreciation he has for the animals that he encounters is obvious. Some of his experiences with jaguars, venomous snakes, or rabid bats are a bit hair-raising, and I can certainly share his awe in confronting a fer-de-lance at close quarters. One almost wishes for a more detailed description of how Ted managed to avoid being impaled on a huge agave or stuck to a saguaro.

The chapter on *Vampyrum spectrum* is perhaps the best general description of this magnificent animal that I have seen anywhere. I remember encountering my first captive *Vampyrum* at Bernardo Villa's home in Mexico. After being released onto the screened-in gallery, it flew to and fro between Bernardo and Bill Wimsatt, eagerly searching for the white mouse that it knew was about to appear as its reward. Ted's account of this species will inspire all of us to support any efforts at its conservation.

Those portions of the narrative describing how the Fleming family grew and matured as it followed Dad through the tropics from Central America and on to England and then Australia and finally to the desert Southwest are fascinating. Ted's writings about these experiences are especially poignant to those of us who also occasionally and sadly left family behind as we chased our own versions of El Duende.

Ted's many comments about his coworkers are mostly complimentary and express an obvious respect and admiration that persists over these many years. A few remarks were less than flattering, but he is speaking from his experiences at the time, not from the perspective of several years or decades later. I have known some of these latter characters, and in some cases, he was actually very kind. It is important that young workers planning extensive field projects be aware that research by teams of amateur volunteers, students, and peers is after all "being in the people business" and as such is not always wine and roses (or, in Ted's case, beer and tacos).

I am recently retired from teaching ecology but have been invited to teach the course once again, as sabbatical replacement. I am strongly inclined to reduce my list of required readings and substitute instead several copies of *A Batman in the Tropics*. It should be required reading for all ecologists, both students and old timers alike. Field biologists will be grateful to Ted Fleming for sharing his enthusiasm and curiosity and especially his findings with us. We wish him well as he continues his search for El Duende.

Reviewed by G. Roy Horst, **Retired;** rhorst@twcny.rr.com

FUTURE MEETINGS and EVENTS

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. The local host is Winston Lancaster. All meeting activities will be held at the Holiday Inn Sacramento Capitol Plaza, where a block of guestrooms has been reserved for NASBR participants. Additional information is available on the society's web site **http://www.nasbr.org/** or you may 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. As additional information becomes available, it will be posted on the society's web site **http://www.nasbr.org/** or you may contact Margaret Griffiths: **mgriff@illinoisalumni.org**

ANNOUNCEMENTS

2006 Student Scholarship Program
Bat Conservation International

Bat Conservation International (BCI) announces availability of student research scholarships for 2006. Ten to fifteen grants, ranging from $500 to $2,500, will be awarded to research that is directly related to bat conservation and that documents roosting and feeding habitat requirements of bats, their ecological and economic roles, or their conservation needs. Students enrolled in any college or university worldwide are eligible to apply. PROJECTS MUST BE RELEVANT TO BAT CONSERVATION.

Application **deadline** for 2006 scholarships is **15 December 2005**. Information and forms are available at **http://www.batcon.org/schol/schol.html** . For questions, please contact Andy Moore via e-mail: **amoore@batcon.org** or telephone: 512-327-9721.

Graduate Assistants – May 2006

Two Graduate Assistants needed for 2-year study of bats in southeastern Michigan, beginning about 15 May 2006. Candidates must have a bachelor's degree in a biological field (or be nearing completion of the degree) and meet requirements of the university and the department for admission into our master's program. Work will involve mist-netting, radio-tracking, behavioral observations, and dietary analyses, with an emphasis on evening bats and Indiana bats. During summer, successful candidates will receive a stipend and reimbursement of field expenses, and during the academic year, they will be offered positions as graduate teaching assistants in the Department of Biology. Send statement of interest, resume, and names and e-mail addresses of two references to:

Dr. Allen Kurta,
Department of Biology
Eastern Michigan University
Ypsilanti, MI 48197
E-mail: akurta@emich.edu

Equipment For Sale

Stuart Perlmeter

After 12 years I decided to hand up my mist nets and return to sleeping during the summer months. I have some equipment I would like to sell so I can clear out my basement and make room for more woodworking equipment. Please contact me by phone or email if you are interested in any of the items. **Prices listed below do not include shipping**.

Avinet Mist Nets (New-never opened)

1– CH 2 (2 meter):	$25 each
4– CH 6 (6 meter):	$40 each
2– CH 9 (9 meter):	$50 each
2– CH 12 (12 meter:)	$75 each
1– CH 18 (18 meter):	$100 each
Take all the mist nets:	**$500**

Poles

5/8 " X 9 ft pole, pounder and carrier: **$100**

Radio-tracking Antenna

3 5-element Yagi radio-tracking antennas & cables: **$90 each**

Radio-transmitters

17 used and new Holohil radio-transmitters (most 0.67 g or smaller): **all for $150**

Bands

Over 1000 different plastic color split–ring bands: $**125**

Insect Light

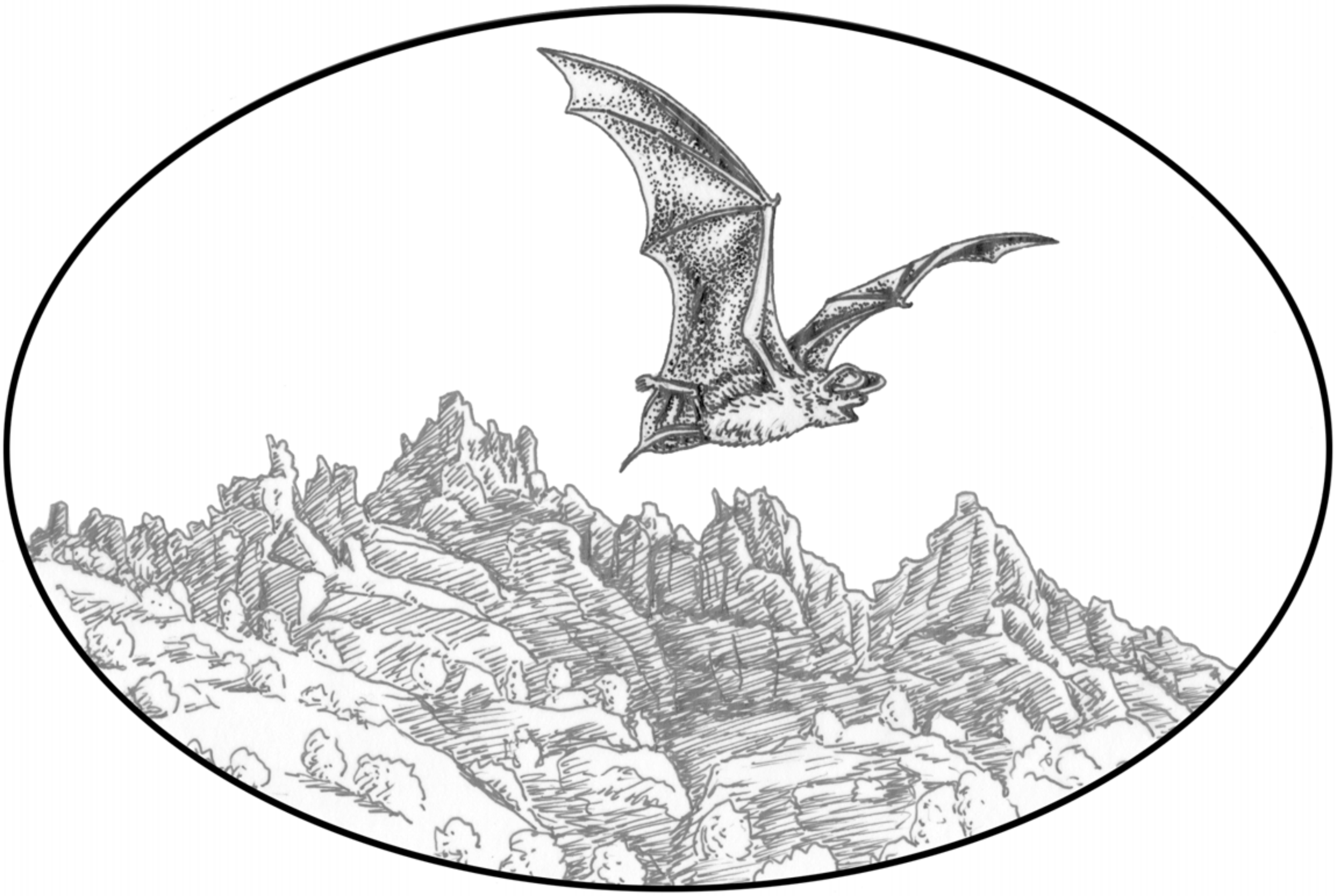
DC Insect Light: **$25**

Type J Digital Thermometer

1– Barnant 90 J Type digital thermometer with 2 probes and over 200 feet of extension cables (great for monitoring roost temperatures remotely): **$50**

Please contact: Stuart Perlmeter
Mailing Address: 2311 Alder Street, Eugene, Oregon 97405
TEL: 541-686-8463 (Home) or 541-912-1618 (cell)
E-mail: stuartperlmeter@mac.com

BAT RESEARCH NEWS



VOLUME 46: No. 4 WINTER 2005

BAT RESEARCH NEWS

VOLUME 46: No. 4 **Winter 2005**

Table of Contents

Front Cover

The logo of the 35th Annual North American Symposium on Bat Research presents a regional theme of central California. Illustrated by Fiona Reid, the logo depicts a western mastiff bat, *Eumops perotis*, flying before a background of Sutter Buttes. In North America, *E. perotis* ranges from central California, southern Arizona and Texas, and western Mexico. One of the northerly most populations occurs in the Sutter Buttes, a range of remnant volcanoes about 100 km north of Sacramento. Known as the world's smallest range of mountains, Sutter Buttes acts as an island of highland habitat in the table-flat farmlands of the Central Valley. It is a biogeographic relict for many taxa, and as one of the northern-most homes of the largest bat in North America, it makes a fitting logo for the 35th NASBR, held in Sacramento. Thank you, Fiona, for once again sharing your work with us.

The False Vampire Bat, *Vampyrum spectrum*, in Oaxaca, México

Ana María Alfaro, José Luis García-García, and Antonio Santos-Moreno

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The false vampire bat, *Vampyrum spectrum* (Phyllostomidae), is the largest bat of the New World. This species seems restricted to primary tropical forests, open areas, and marshes, from sea level to 1,650 m (Handley, 1976; Peterson and Kirmse, 1969; Vargas-Espinoza et al., 2004). The false vampire bat generally is considered rare (Reid, 1997) and is listed as endangered in México (Ceballos et al., 2002). The known range of this phyllostomid is from Veracruz, México, southward to Trinidad, central Brazil, and Peru (Koopman, 1993; Navarro and Wilson, 1982; Reid, 1997).

On 4 September 2005, we were collecting pellets of a barn owl (*Tyto alba*) in a cave at the locality Ejido Plan de San Luis, in the Municipio Santiago Jocotepec, District of Choapam, in the state of Oaxaca (17°46'34"N 95°57'35.5"W). The cave was located at 80 m above sea level in an area that was dominated by evergreen tropical forest. Pellets apparently had been deposited over a long period because some pellets were intact whereas others were disintegrating. In addition, some skeletal material was scattered among the pellets. These unassociated items probably represented the remnants of pellets that had totally disintegrated over time, leaving no trace of soft tissues, like hair or feathers, although it is possible that such material may have arrived in the cave by means of other than an owl.

Among this scattered material, we discovered the skull of a single adult false vampire bat, as well as the remains of a number of other animals, including the rice rat (*Oryzomys* sp.), hispid cotton rat (*Sigmodon hispidus*), and other bats (*Artibeus jamaicensis*, and *Micronycteris* sp.). The skull of the false vampire was complete, other than missing canines, and the sagittal crest was well developed, suggesting that this large skull came from an old animal. Cranial measurements (in mm) were: greatest length of skull, 49.3; breadth of braincase, 15.6; least interorbital breadth, 11; zygomatic breadth, 24; and length of maxillary tooth row, 20.4. This specimen (AS-M 488) was deposited in the Colección de Mamíferos of the Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional, Unidad Oaxaca.

The nearest locality of occurrence for the false vampire bat is the Estación de Biología Tropical Los Tuxtlas, 30 km NE Catemaco, in the state of Veracruz (Navarro, 1979), ca. 114 km NE of the current locality. The only other previous records of this species in México are from the states of Chiapas (López et al., 1998) and Campeche (Hernández-Huerta et al., 2000). Hence, this is the first record of the false vampire bat in the state of Oaxaca, and it increases the known mammalian fauna of Oaxaca to 192 species.

Acknowledgments.—This work was sponsored in part by the Mexican Consejo Nacional de Ciencia y Tecnología and the Coordinación General de Posgrado e Investigación, Instituto Politécnico Nacional de México. E. Martínez-Meyer critically read the manuscript.

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Extralimital Record of the Gray Bat (*Myotis grisescens*) in Indiana

Nicole M. Tuttle[1], Dale W. Sparks[2], and Christopher M. Ritzi[3]

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Although 12 species of bats are known from Indiana (Mumford and Whitaker, 1982), three of these (Rafinesque's big-eared bat, *Corynorhinus rafinesquii*; southeastern bat, *Myotis austroriparius*; and gray bat, *Myotis grisescens)* are essentially restricted to the southern tier of counties along the Ohio River. However, on 21 July 2005, we mist-netted a gray bat in suburban Indianapolis adjacent to the Indianapolis International Airport (UTM, NAD 1983: 16T, E557723, N4397194), in Marion County, Indiana, just before the arrival of a severe thunderstorm. The area in which we were netting is managed by the airport, and the surrounding landscape consists of forest fragments, agricultural fields, residential subdivisions, and commercial properties (Whitaker et al., 2004). The bat was a nonparous, adult female (mass = 9.75 g; forearm length = 44 mm) that was parasitized by both anal mites (*Spinturnix globulosis*) and wing mites (*Spinturnix banksi*).

We believe that the animal probably was not a resident of the local area for a number of reasons. First, the capture locality is ca. 160 km north of the nearest known summer colony, located near Sellersburg, Indiana (Whitaker et al., 2001). Second, Indianapolis is not in a karst region, and gray bats are highly dependant upon caves for summer and winter roosts (Decher and Choate, 1995). In addition, we also attached a 0.47-g radio-transmitter to the bat and searched the surrounding area for the next week without obtaining a signal. Hence, this bat probably was a disoriented migrant, a bat displaced by storms that were the remnants of Hurricane Dennis, or perhaps a bat searching for new roosts. Although gray bats are listed as endangered by the U.S. Fish and Wildlife Service, populations in Indiana have experienced a marked increase in recent years (Whitaker et al., 2001). If these populations continue to expand, some roosts may become overcrowded, leading to individuals seeking new sites, and consequently, extralimital records may become more common for gray bats.

We thank A. Bootman, J. S. Helms, S. S. Nard, T. M. Poloskey, and D. J. Witmere for field assistance. This research was funded by the Indianapolis International Airport. All methods were approved by the Indiana State University Committee on Animal Care and Use.

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Abstracts of Scientific Papers Presented at the 35th Annual North American Symposium on Bat Research Sacramento, California 19–22 October 2005

Abstracts are listed in alphabetical order by first author. Contact information for authors who attended the 35th NASBR follows the abstracts.

A Comparison of Size at Birth and Postnatal Growth Rates in Cave- and Bridge-roosting Brazilian Free-tailed Bats

Louise Allen, Eric P. Widmaier, and Thomas H. Kunz, Boston University, Boston, MA

The Brazilian free-tailed bat (*Tadarida brasiliensis*) occupies a variety of roost types, including caves, bridges, and buildings throughout south-central Texas from mid-March through late-October. Roosts are expected to differ in quality, due to variation in temperature and thermal stability of the roost, colony size and types and levels of disturbance. We hypothesize that roost quality together with other variables such as an individual's age, body condition, and reproductive status can influence the production of stress hormones (glucocorticoids) and therefore the health of both individuals and populations. Acute glucocorticoid (cortisol and corticosterone) release is beneficial in helping animals survive stressful situations, for example by elevating blood glucose levels for an immediate source of energy. Chronic stress, however, can lead to elevated glucocorticoid concentrations. This can cause decreased reproductive success, decreased immune system function, and increased susceptibility to disease and parasites. In the present study, we assessed size at birth and postnatal growth rates of pups (variables assumed to reflect overall health and nutritional status of mothers during pregnancy and lactation) that were born in a cave and a bridge roost. We test the hypothesis that these traits in pups are influenced by the different roost conditions to which mothers and pups were exposed during the pre- and postnatal periods. Based on expected differences in environmental stressors in cave and bridge roosts, we predicted that pups that are born to females in caves should be larger at birth and grow faster than pups born to females that roost in bridges. Pups from the two sites were captured and banded on the day of birth, measured (body mass, forearm length, and total epiphyseal gap length of fourth metacarpal and first phalanx) and recaptured at 2–6 day intervals until they were approximately 42 days old. Pup mass at birth and linear growth rates of pups derived from these measurements were compared between the two roost sites. Preliminary analysis indicates that size of pups at birth differs between the two sites, with size of pups at birth being significantly larger at the bridge site, in contrast to our original hypothesis. Postnatal growth rates of pups at the two sites will be compared when data collection and analyses are complete. Results will be discussed with respect to differences in environmental variables and environmental stressors to which bats were exposed at the two sites.

A Phylogeny of Megabats Based on Three Nuclear Genes

Francisca C. Almeida, Norberto Giannini, Rob DeSalle, and Nancy Simmons, American Museum of Natural History, New York, NY

The presently available molecular evidence for Megachiroptera (megabat) phylogenetic relationships is mostly based on mitochondrial genes. Although four mitochondrial genes (*12S*,

t-Val, *16S*, and *Cyt b*) have been used in phylogenetic studies on this suborder, only one nuclear gene has been included, the oncogene c-*mos*. The sequence of c-*mos*, nevertheless, added very little information to the mitochondrial dataset; besides being short with ca. 500 bp, c-*mos* sequences show very little variation among megabats. Although some relationships received high support in the previous analyses using these genes, some parts of the megabat tree lacked resolution and/or support. In addition, several important groups of megabats were not represented by sequence data. In the present study, we sequenced three nuclear genes, *RAG1*, *RAG2*, and *vWF*, and increased the species sampling, covering most of the megabat diversity. This is an important step towards a more comprehensive analysis combining evidence from nuclear and mitochondrial genes and morphology. Using standard sequencing procedures, we obtained a set of 3080 bp (1084 bp from *RAG1*, 764 bp from *RAG2*, and 1232 bp from *vWF*) for 47 species of megabats. In this presentation, we show parsimony analyses of individual genes and the combined dataset. As outgroup, we used sequences of representatives of all bat families available from previous studies. Tree search strategy included replicated swapping and additional refinements (parsimony ratchet and tree fusing). Our results based on individual-gene analyses show little supported resolution, but the combination of signals improved support on many clades. These preliminary results suggest some modifications of the current understanding of megabat relationships.

Use of Infrared Thermal Imaging to Census the Endangered Mexican Long-nosed bat (*Leptonycteris nivalis*) in Big Bend National Park, Texas

Loren K. Ammerman, Thomas H. Kunz, Nickolay Hristov, Molly M. McDonough, Michael T. Dixon, and Raymond Skiles, Angelo State University, San Angelo, TX; Boston University, Boston, MA; Big Bend National Park, TX

Numbers of the Mexican long-nosed bat, *Leptonycteris nivalis* reportedly are declining, although no reliable data exist to adequately address this concern. Emory Cave, located in Big Bend National Park, is one of the few known roost locations for this species in the United States. *L. nivalis* inhabits the cave during the summer months, and spends the remaining months in Mexico. Numbers are known to fluctuate throughout the summer, presumably in response to the flowering phenology of *Agave*. Previous estimates of colony size have been made by measuring surface area covered by roosting bats, although this method has several major shortcomings. This method is highly disruptive to the colony, and some bats either roost in inaccessible crevices or are widely dispersed in the cave and thus cannot be observed and counted. Visual estimates of colony size, by counting bats as they emerge at dusk, are difficult because of low light, dense vegetation, and the large numbers of individuals that circle at the cave opening. An added complication for all techniques is that two other species, *Myotis thysanodes* and *Corynorhinus townsendii*, also use the cave in low numbers. We used a FLIR infrared thermal camera (S-60), coupled to a laptop computer, to census bats as they emerged from Emory Cave at dusk. Sampling was conducted on two successive nights in June, July, and August 2005 for a total of 6 emergences, each lasting approximately 1–1.5 hours. Records were analyzed manually to estimate colony size. For comparison, estimates of surface area were taken on the last morning of each sample period. As expected, thermal recordings and estimates of surface area were different. Census estimates were markedly higher using the thermal recordings — presumably because bats that otherwise roosted in crevices or were inaccessible could be counted using this technology. We conclude that infrared thermal imaging has several advantages for censusing bats. It provides a high resolution, permanent record of the emergence, it results in less human error, and is less disturbing to bats than entering the cave to count bats. Disadvantages are expense, occasional failure of cameras and computers in the field, and time required for analysis. An additional disadvantage is that currently the results cannot be directly compared to previous census data. Despite these shortcomings, our data suggest that thermal imaging can provide a more reliable and accurate estimate of colony size at Emory Cave than has previously been possible.

Does the Repertoire of Ultrasound Social Calls Made by *Rhinolophus ferrumequinum* Form the Basis of a Language?

Margaret M. Andrews and Peter T. Andrews, Liverpool John Moores University, UK; Liverpool University, UK

Ultrasound social calls, in the frequency range 11–39 kHz, have been recorded in a British nursery roost and in two winter roosts of the greater horseshoe bat (*Rhinolophus ferrumequinum*) using time expansion detectors. These calls are below the echolocation frequency for this species (83–84 kHz). The development of infant bat calls, from broad band isolation calls to echolocation calls, takes place within 15 days of birth and seven kinds of infant call have been identified. There are two types of constant frequency (CF) calls and five types of frequency modulated (FM) calls. The FM calls have been subdivided into three groups according to the number of components in which the frequency rises or falls, and designated single component, multiple component, and modified echolocation calls. Although seven ultrasound social calls made by adult bats in the nursery roost are similar to the infant calls, another four kinds appear to be developments of the multiple component FM call and one is a modified CF echolocation call. There is an increase in the repertoire of the greater horseshoe bats in the winter roosts. New calls are added to the repertoire by the addition of components to the FM multiple component calls giving two new calls and by increasing the complexity of multiple component calls to form six trill calls. Whether the infant calls are innate or learnt is at present an unanswered question. However, the development of a vocabulary of 20 types of adult ultrasound social call appears to indicate a process of learning.

The Influence of Temperature Fluctuations on Bats' Use of Foraging Areas

Devin W. Arbuthnott, University of Regina, Regina, SK

To maximize foraging efficiency it is reasonable to expect temperate bats to travel to places with the highest insect abundance. Given that insects are ectothermic, it is also reasonable to expect that warmer locations will support higher insect densities. A nightly temperature inversion occurring in the Cypress Hills (Saskatchewan, Canada), therefore, presents an opportunity to test the hypothesis that temperature influences bat foraging behavior. Specifically the valley, and the creek it contains, becomes colder than the upland plateau at night. Big brown bats (*Eptesicus fuscus*) are known to roost in aspen trees at an intermediate elevation with equal access to both of these areas. I predicted that if temperature is important for foraging, bats would begin the night in the valley (which also allows for a drink) and later travel to the warmer plateau to forage. I measured ambient temperature (T_a) and insect abundance at each elevation (valley, roost, and plateau) and bats were monitored using radiotelemetry. The sites to which I tracked foraging bats were qualitatively described to assess characteristics of quality foraging sites. Typically several bats were tracked at the same time making it possible to determine whether behavior varied between bats or if all individuals used similar foraging sites. I followed 13 individual bats (all adult females) on 25 different nights for a total 71 tracking-nights. Although individual behavior varied nightly and different individuals exhibited different general patterns, all the bats followed spent at least a portion of the night in a similar foraging area, sometimes traveling up to 8 km to reach this site. Because these bats chose to travel farther than expected, a direct test of the effects of the temperature inversion on foraging behavior was difficult. However, indirect evidence from the foraging site suggests that the inversion has little to no effect on the bats' behavior, and as the bats did forage at the same site regardless of T_a, other factors were likely more important. Preliminary data for individuals from a separate colony in the same study area suggest that big brown bats belonging to different colonies forage at separate sites.

Pre- and Post-Construction Surveys for Predicting Bat Fatality at Wind Farms

Edward B. Arnett and John P. Hayes, Bat Conservation International, Austin, TX; Oregon State University, Corvallis, OR

Wind has been used to commercially produce energy in North America since the early 1970s and is one of the most rapidly growing sectors of the power industry. However, fatalities of bats have been documented at wind farms worldwide and alarming numbers have been killed in certain regions of North America. Interactions between bats and wind turbines are poorly understood. Post-construction monitoring has provided most of what little information has been gathered on bat fatalities at wind farms. Pre-construction surveys at wind farms have been conducted and most commonly employ mist nets and acoustic detectors to assess the presence and activity of local bat species, but using this information to predict bat fatality and, thus risk at a site has proved to be challenging. Also, we are currently unaware of any study linking pre-construction monitoring data with post-construction fatality, a critical link necessary for understanding potential risk of wind farms to bats. We discuss the challenges of pre-construction assessments of bat activity at proposed wind farms. Additionally, we present the study design, methods, and preliminary results from the first year of a three-year study implemented to determine if indices of pre-construction bat activity can predict post-construction bat fatalities at turbine locations on a proposed wind farm in south-central Pennsylvania.

Variability in Social Calls within and between Colonies of Pallid Bats

Bryan D. Arnold and Gerald S. Wilkinson, University of Maryland, College Park, MD

The vocal repertoire of many bats includes both ultrasonic echolocation calls and audible social calls, the function of which for many species is largely unknown. Pallid bats (*Antrozous pallidus*) are unique among vespertilionid bats in that they emit an intense, partially audible (sweeping from 30–5 kHz) social call that is often repeated several times in rapid succession. This directive call is frequently emitted as individuals perform a pre-dawn rallying behavior, which has been suggested to aid colony formation as bats return from foraging. However, social calls are also emitted by pallid bats during mother-infant reunions, when leaving the day roost, and when entering and exiting the night roost. The primary goal of this study was to determine if variation in the acoustic structure of social calls exists either within or between colonies of pallid bats independent of the presence of lactating pups. To address this question pallid bat social calls were digitally recorded with a laptop computer at three separate cliff complexes in central Oregon from June to August, 2005. When a social call was recorded the presence or absence of other bats in the vicinity of the calling bat, as well as the location of the calling bat to a nearby roosting crevice, were noted. Inter- and intra-colony variation in call frequency, amplitude, and duration were estimated using MANOVA on measurements taken from sound spectrograms. The extent to which the observed call variation might be used by individual bats to recognize colony members is discussed.

Rediscovery of the Flat-headed Myotis, *Myotis planiceps,* and Preliminary Observations on its Natural History

Joaquín Arroyo-Cabrales, Elisabeth K. V. Kalko, Richard K. LaVal, Leonardo López, Jesús E. Maldonado, Rodrigo A. Medellín, Oscar J. Polaco, and Bernal Rodríguez-Herrera, Program for the Conservation of Mexican Bats, Mexico

Few Mexican bat species have been studied, other than to record their presence and distribution, and some of them may become extinct with no knowledge of their biology. The flat-headed bat (*Myotis planiceps*) is an insectivorous species, microendemic to a tiny region in northeastern Mexico. It was declared extinct by IUCN in 1996, is considered endangered by the Mexican government, and had not been seen in 30 years. Intensive fieldwork and systematic studies have been recommended in order to understand the conservation needs of rare or threatened species. Given the uncertainty associated with the case of the flat-headed bat, the Program for Conservation of Mexican Bats (PCMM for its Spanish acronym) launched a long-term project to understand the biology, distribution, and conservation and habitat requirements of *Myotis planiceps*. In the summer of 2004 we were able to find several individuals. This rediscovery represented a major finding and a very rare opportunity to learn about a supposedly extinct species and contribute to its recovery through research and environmental education. This year, a follow-up search was undertaken in June to locate and characterize the roosts of this very small species (body mass around 3 gr) using radio-transmitters (Holohil Systems), and also learning about its reproductive cycle and diet. We were able to find several roosts and over 100 individuals in one maternity colony. The importance of soap trees and pinyon pine forest for flat-headed bat conservation is highlighted.

Use of Olfaction, Vision, and Echolocation in Prey Location by the Common Vampire Bat (*Desmodus rotundus*)

Joseph Wm. Bahlman and Douglas A. Kelt, University of California at Davis, Davis, CA

The common vampire bat, *Desmodus rotundus*, feeds on mammalian blood and has become one of the largest agricultural pests in Latin America. To prevent bats from biting livestock, we must understand how the bats locate the livestock. I tested the relative use of smell, vision, and

echolocation by *D. rotundus* when locating prey. Olfaction was evaluated by placing dishes of blood at the ends of four tunnels leading from a central chamber; one randomly selected tube also contained the scent of livestock. Results overwhelmingly indicate that *D. rotundus* uses scent when locating prey. Vision and echolocation were evaluated with wild bats using life-sized models—one cow-shaped and three non-animal shapes. The models were placed in a pasture where vampire bats were known to forage, and I recorded the number of bats caught in nets attempting to feed on each model. These observations indicate that the prey's shape is unimportant to the foraging bats, but additional work is needed to verify this conclusion.

Day-roosting Behavior of Female *Myotis volans* in Xeric and Mesic Forests of the Intermountain Northwestern United States

Michael D. Baker, Michael J. Lacki, and Joseph S. Johnson, University of Kentucky, Lexington, KY

The harvest of timber is important to the economy of the intermountain northwestern United States, where ecologically based forest management requires basic information regarding habitat use by wildlife, including insectivorous bats. Currently, colony formation and use of diurnal roosts during the breeding season by female long-legged myotis (*Myotis volans*) are insufficiently understood. We investigated these behaviors for long-legged myotis inhabiting xeric and mesic forests by radio-tracking 136 females in six watersheds in Washington, Oregon, and Idaho between 2001 and 2005. Eighty-seven bats in xeric (i.e., annual precipitation < 30 cm) forests used 195 snags and declining live trees, and 34 rock crevices as day-roosts. Forty-nine bats in more mesic (i.e., annual precipitation > 90 cm) forests used 168 snags and declining live trees as day-roosts; no female long-legged myotis used a rock crevice for roosting in mesic forests. Bats in both forest types used true firs (i.e., *Abies grandis* and *A. concolor*), with these tree species comprising 38% of day-roosts in xeric forests and 49% of day-roosts in mesic forests. Differences in use of tree roosts between habitats were evident; 53% of day-roosts in xeric forests were in ponderosa pine (*Pinus ponderosa*), whereas day-roosts in mesic forests were distributed more evenly among western larch (*Larix occidentalis*, 20%), Douglas-fir (*Pseudotsuga menziesii*, 16%), western white pine (*P. monticola*, 10%), and western red cedar (*Thuja plicata*, 5%). The formation of maternity colonies by long-legged myotis (defined as > 10 bats exiting a roost tree) was more prevalent in xeric forests than in mesic forests (29% versus 8% of day-roosts, respectively). Roosts situated beneath exfoliating bark on ponderosa pine represented 84% of colony roosts in xeric forests. In contrast, colony roosts in mesic forests were distributed among a greater diversity of tree species including western red cedar (36%), grand fir (29%), western larch (21%), western white pine (7%), and Douglas-fir (7%). Larger colonies were more prevalent in xeric forests, with half the colonies composed of > 50 bats and 19 colonies composed of > 200 bats. Colony roosts in mesic forests typically contained fewer bats, with only four roosts supporting > 50 bats and one > 200 bats. These data suggest that management prescriptions for long-legged myotis in the northwestern U.S. will require consideration of the variation in roosting behavior of these bats occupying xeric versus more mesic forests in this region.

Continental Biodiversity in Phyllostomid Bats Originating from the Antillean Islands

Robert Baker, Olaf Bininda-Emonds, Hugh Genoways, Carl Phillips, Kate Jones, Steve Hoofer, and John Bickham, Texas Tech University, Lubbock, TX; Technical University of Munich, Germany; University of Nebraska, Lincoln; Columbia University, NY; Texas A&M University, College Station, TX

In biogeography, it is axiomatic that continental faunas serve as the source for, and hold selective advantages over the faunas on geographically adjacent islands. There are two examples contrary to this axiom in Antillean new world leaf-nosed bats (Phyllostomatidae). The discovery of the evolutionary events associated with a mainland invasion to the islands that radiated into several genera in the Antilles, followed by reestablishment and diversification into other genera on the mainland, is based on gene trees generated from mitochondrial ribosomal genes and the nuclear *RAG2* gene. The first example is within the nectar-feeding bats, subfamily Glossophaginae. We hypothesize a common ancestor for *Brachyphylla*, *Erophylla*, *Phyllonycteris*, and *Monophyllus* with a continental origin. These four genera shared a common ancestry in the Caribbean between 15 and 19 million years ago. We further hypothesize that *Monophyllus* is sister to a clade giving rise to *Glossophaga* and *Leptonycteris* and that this common ancestor for these three genera was Caribbean and reinvaded the continent before diversification into *Leptonycteris* and *Glossophaga*. The common ancestor for *Leptonycteris* and *Glossophaga* is dated between 9 and 12 million years ago. The second example occurs in the subfamily Stenodermatinae, subtribe Stenodermatina. We hypothesize that the common ancestor for the eight Stenodermatina genera invaded the Caribbean between 4 and 6 million years ago, and radiated into *Ariteus*, *Ardops*, *Stenoderma*, and *Phyllops*, and that *Centurio*, *Pygoderma*, *Sphaeronycteris*, and *Ametrida* were a product of a reinvasion (dated at 4.3 million years ago) of the continent from a lineage that was sister to *Stenoderma*. In both examples, there has been morphological evolution on the islands to specialization of trophic levels (nectar feeding and strict fruit eating). We think the magnitude of change while in the Antilles provided the ancestral stock that reinvaded the mainland with an opportunity to diversify and avoid competition with the extensive fauna of phyllostomid bats already present on the mainland. Upon returning to the mainland, both lineages evolved into new genera that became broadly distributed forming a different biodiversity component for the mainland. Phyllostomid bats represent a unique level of diversity with adaptation to eating insects, blood, nectar, vertebrates, fruit, and various combinations of omnivory represents more morphological and physiological diversity than is present in any other family of vertebrates. The extent that this evolutionary plasticity was critical to reinvasion and diversification of an island lineage on the mainland remains to be documented.

Another Western Indian Ocean Bat Close to Extinction: Is *Coleura seychellensis* still the Rarest Bat in the World?

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The only microchiropteran endemic to the granitic Seychelles, the sheath-tailed bat *Coleura seychellensis* has declined over past decades, and is critically endangered. Using bat detectors, the islands of Mahé, Praslin, and La Digue were surveyed to establish the current distribution of the bats. Although two new roosts were discovered on Mahé, no bats were observed on Praslin and La Gigue, and the range of *C. seychellensis* appears to have contracted in the last two decades. A total of 19 *C. seychellensis* were counted emerging from three roosts in boulder caves in Mahé during 18 evenings of observations. The bats showed a clear preference for foraging in coastal habitat, some of it anthropogenic. The echolocation calls were also characteristic of bats feeding in open habitat. This study provides no evidence that *C. seychellensis* is dependent on forest or wetland for foraging. Dietary analysis indicated that *C. seychellensis* feeds on Coleoptera, Lepidoptera, and Diptera. A public education program to highlight the consequences of roost disturbance is suggested.

Foraging Behavior of Egyptian Fruit Bats (*Rousettus aegyptiacus*) in Cape Town: How Important are Figs?

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The energy and nutrient demands on male and female bats differ, and they vary depending on the reproductive condition of individuals. Reproductive females require more energy and calcium than do males, and as a consequence, their foraging behaviors may differ. Using radiotelemetry, we studied the foraging behavior of the Egyptian fruit bat (*Rousettus aegyptiacus*) in the vicinity of Cape Town. We attached radio collars to 21 individuals from a colony on Table Mountain and located them at night while they foraged. Most bats spent the majority of their time in the native forests on the eastern slopes of the mountain, but occasionally ventured up to 7 km into neighboring suburbs, especially when fig trees (*Ficus sur*) were in fruit. Male and female foraging behaviors differed in that males foraged for shorter periods of time during the pregnancy and post-lactation periods. However, contrary to our predictions, foraging periods were equally long during lactation and there was no evidence that home range size differed between the sexes. In addition, despite the relatively high calcium content of figs, there was no evidence that lactating females made greater use of fig trees than males did. Our results suggest that the shorter foraging times of males may be due to territorial behavior in the roost, rather than differences in energy and nutrient demands. Figs represent a periodically abundant fruit that both males and females feed on. Although trees in suburban areas are used by *R. aegyptiacus*, individuals rely on native forest stands and protection of them may be important if *R. aegyptiacus* populations in suburban areas are to be preserved.

Burned Streams Produce More Aquatic Insects and Consequently Higher Foraging Activity by Bats

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The effects of fire can appear to devastate entire landscapes. However, research has suggested that wildfire may often cause renewed vitality within the ecosystems it affects. In 2000, a fire burned through a significant portion of the Frank Church "River of No Return" Wilderness Area in central Idaho. Within the wilderness, tributaries in the Big Creek watershed experienced varying levels of impact from the fire, from being completely burned to being untouched by fire. These different levels provided the opportunity for a comparative study of organismal response to fire. Organisms living in streams are provided with more sunlight and concentrated nutrients that wash down from burned hillside. Among vertebrates, bats may be one of the first groups to utilize a burned habitat because flight and roosting strategies reduce the need for shelter in the immediate vicinity of food resources. Our study was designed to detect differences in the emergence of adult aquatic insects and bat feeding activity between burned and unburned areas. Characteristic burned and unburned sites were selected on tributaries of Big Creek. Aquatic insect emergence was sampled by placing floating traps on the streams and bat activity was sampled using the Anabat acoustic system placed adjacent to the insect sampling sites. Burned sites showed higher insect emergence and bat activity than the unburned sites. The effects of factors unrelated to food availability, such as a more open canopy (which may facilitate foraging), remain to be determined. Regardless, our observations suggest that the mid-term effects of wildfire may include a positive influence on both aquatic insects and bats that feed on emergent adults.

Use and Selection of Highway Bridges by Rafinesque's Big-eared Bat (*Corynorhinus rafinesquii*) in South Carolina

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Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) occur throughout the South and into some Midwestern states. However they are rare throughout their range and are considered to be a species of special concern in every state in which they occur. Previous studies have documented the use of bridges by Rafinesque's big-eared bats in Louisiana, Mississippi, and North Carolina, but information on bridge use across the range is lacking. Further, two of the three studies on bridge use were conducted in National Forests. Thus, our objective was to determine the use and selection of bridges as day roosts by Rafinesque's big-eared bats on all public roads in South Carolina. We surveyed 1,129 bridges within all 46 counties from May to August 2002. During the summer of 2003, we monitored 236 bridges in previously occupied areas of the state one to five times to evaluate bridge roost fidelity. Colonies (including maternal groups) and solitary big-eared bats were found beneath 38 bridges in 2002 and 55 bridges in 2003. Occupancy in both years was strongly influenced by bridge size ($p < 0.001$) and construction type ($p < 0.001$); bats selected large, concrete girder bridges, and avoided flat-bottomed, slab bridges. Rafinesque's big-eared bats occupied bridges in the Upper and Lower Coastal Plain, but were absent from bridges in the Piedmont and Blue Ridge Mountains. Big-

eared bats demonstrated a high degree of roost fidelity (65.9%). We also found that checking bridges three times at 2-week intervals ensured the detection of bats, but checking more than three times did not increase detection probabilities. The high degree of fidelity and use by maternal groups suggest that highway bridges are important roosting sites for Rafinesque's big-eared bats in the South Carolina Coastal Plain. Our results also suggest that if repair or maintenance work is planned for girder bridges during the summer, they should be inspected three times over a four to six week period. In addition to conventional trapping methods, we advocate the use of bridge surveys to locate this rare bat across its range, especially in areas where natural roosts are lacking.

A Molecular Approach to the Phylogenetic Position of *Myopterus*

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The family Molossidae consists of the free-tailed bats and is pan-tropical in distribution. In the family there are 100 species divided into 16 genera, one of which is *Myopterus*. Both species of this genus have an Old World distribution, occurring in western and central Africa. Little is known about *Myopterus* and there are little molecular data for the phylogenetic analysis of the family, though several morphological analyses have been conducted. Previous morphometric analyses found *Myopterus* had a close relationship to the genus *Molossops* (including *Cynomops* and *Neoplatymops*). However, some morphological features, such as deep basioccipital pits in *Myopterus*, are inconsistent with this arrangement. In addition, *Myopterus* has been placed with *Cynomops* in the Molossinae subfamily based on dental characters. The purpose of our project was to obtain DNA sequence for *Myopterus* to determine if the molecular phylogeny was congruent with the morphometric data, and therefore determine a phylogenetic relationship between these genera. The mitochondrial ND1/*16S* and *cytochrome b* gene regions were amplified, cloned, and sequenced from DNA extracted from tissue samples of two individuals of *Myopterus daubentonii* (= *albatus*). The sequences were then aligned with sequences from other genera for these genes, including *Molossops*, *Promops*, *Cynomops*, and *Molossus*. Our results show conflicting results between the ND1/*16S* analysis and the *cytochrome b* analysis regarding the placement of *Myopterus* among the other genera.

What Gliding Mammals Can Tell Us about the Origin of Flapping Flight in Bats

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The evolution of bats from an arboreal gliding ancestor presents interesting functional challenges. The wings of bats and those of gliding mammals have distinct morphologies and the functions of flapping and gliding may be subject to different sets of optimization parameters. Understanding the mechanics of a gliding to flapping transition requires better understanding of the aerodynamics of flexible, extensible wings, such as those made of skin. Much of the theoretical work that has been done on animal flight has been based on the assumption that animal wings work similarly to human engineered aircraft wings. But mammal wings are small, operate at relatively slow speeds, can have very low aspect ratios, and are compliant; therefore there is good reason to believe that they differ in important ways from aircraft wings. In addition, a more detailed understanding of the kinematics of living mammalian gliders provides insight into how bat ancestors might have used their wing membranes to control the velocity, distance, and direction of their glides. To investigate the kinematics of gliding in mammals, I trained a group of flying squirrels (*Glaucomys volans*) to glide in a controlled setting along a known trajectory. A short segment of the middle of the glide was filmed using two high-speed digital cameras. I used the two camera views to compute the three dimensional coordinates of markers applied to the squirrels' bodies to obtain detailed, high resolution 3-D kinematics. Compared to typical stall angles for human engineered airfoils, the angles of attack used by the squirrels were unexpectedly high, ranging from 35.4 – 53.5°, far above the angle of attack at which an aircraft wing would typically stall. Within glides, there was a strong correlation between limb movements that tended to increase the angle of attack of the wing membrane and nose-down pitching rotations, suggesting that the animals actively control their pitch by moving their limbs. There was far less variability in lift-to-drag ratio than in either lift coefficient or drag coefficient, suggesting that squirrels adjust their lift and drag in a coordinated way that produces a stable lift-to-drag ratio, and thereby a stable glide angle. The results of this study point to the possibility that stability in flight might have been an important factor in the early evolution of flapping flight in bats in addition to increasing lift and generating thrust.

Roosts and Movements of Bats of the Genus *Leptonycteris* in New Mexico

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Two species of long-nosed bats (*Leptonycteris curasoae* and *L. nivalis*) occur in southwestern New Mexico. We have obtained information on roosting habits and movements of both species in our studies since 2002. For identification purposes, pelage, mass, length of forearm, and length of the terminal phalanx of the third digit appear to clearly separate the two species in New Mexico. During our work we have captured both species at two sites in the Animas Mountains and have instrumented 33 *L. curasoae* and 19 *L. nivalis* with miniaturized transmitters. The two species appear in New Mexico around mid-July and depart by mid-September, a period of time that appears to coincide with maximal flowering of *Agave* spp. in the area. Searches of abandoned mines in the vicinity revealed no sign of roosting by *Leptonycteris* spp. at any of the surveyed workings. Instrumented bats of both species appear to rely strictly on natural caves and fissures for day roosts. We monitored four day roosts, two of which were discovered during the study. Two of these roosts seem to be used almost incidentally and only small numbers of bats (4 to 25) have been counted there. Counts of bats exiting the larger day roosts show numbers of bats vary over the summer from lows of 5 to 10 bats up to 1200 to 1400 bats at times. We have counted over 600 bats exiting the new roost we found in the Big Hatchet Mountains; this roost extends the known range of *Leptonycteris* over 30 km to the east in New Mexico. In addition, we are aware of one night roost in an abandoned building that both species use communally. Tracking of instrumented bats reveals that both species are commuting, often nightly, between a roost in the Animas Mountains and one in the Big Hatchet Mountains. This work has been funded by the Bureau of Land Management, Las Cruces Field Office.

***Alloparental Care and Perception of Infant Isolation Calls in Greater Spear-nosed Bats**
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*** Kirsten Bohn** received the **Lubee Bat Conservancy Award**

Directing parental care towards related individuals should be under strong selection. In many species parent-offspring recognition systems facilitate accurate parental care. However, in *Phyllostomus hastatus* researchers have observed group mates' visit and retrieve pups that have fallen from roost sites, even though pups emit isolation calls that should assist in offspring recognition. In this study I determine whether visits to unrelated pups are a result of misidentification or cooperation. First, I examine variation in acoustic features of infant isolation calls. Second, using psychoacoustic experiments, I investigate call perception to determine whether females can discriminate among isolation calls. Finally, I examine individually marked females' responses to fallen pups and use microsatellite markers to determine the relatedness between females and pups. I found that isolation calls contain sufficient information to provide individual signatures and that females could discriminate between isolation calls regardless of social group. However in the field, many females responded to fallen pups and females visited group mates' pups more frequently than non-group mates' pups. Visiting behavior was not consistent with misidentification but did support "pup-guarding" where females protected group mates' pups from non-group mates that attacked and sometimes killed pups. These results provide evidence of cooperative care among unrelated females in long-lived social groups.

Movements and Home Range of the Hawaiian Hoary Bat
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From 927 observed radiotelemetry positions on six individuals, we present home range, long axis across home range, and core-use area dimensions for the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) on the island of Hawaii. In nightly movements, adult males range over distances of 11 to 16 km (long axis across home range) compared to adult females ranging from 3 to 4 km. Nightly movements are associated with commuting between several disjunct activity centers and the day roost. Mean home range (by fixed kernel minimum area probability = 0.95) of females was 5.6 ha; whereas male hoary bats had a mean home range of 121 ha. Each sex concentrated nightly activity in two or three activity centers associated with foraging as determined by numerous feeding buzzes heard with bat detectors. However, the activity centers used by males were spaced over large distances and female activity centers were separated by small distances. Mean core-use area (fixed kernels = 0.5) of males was larger than that of females (5.6 ha and 0.9 ha respectively). We suggest that females typically move to several productive feeding patches within a small area to maximize feeding efficiency for pregnancy and lactation; whereas males range over much larger areas both to feed and to interact with multiple potential breeding partners.

In-flight Vocalizations of the Chimney Swift, *Chaetura pelagica*: More Like Bats than Birds?

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Among the most aerial of land birds, the highly gregarious and vocal chimney swift, *Chaetura pelagica* is a common sight in Eastern North America. The high-pitched chip notes they produce are a defining feature of the species. These calls, in their simplicity, resemble those produced by various bat species more so than those of other birds. Nevertheless, the context in which these acoustic signals are given, as well as their characteristics have not been well studied. From June until the end of September 2005, the images and sounds of chimney swifts in flight were simultaneously recorded at various locations in London Ontario. Call characteristics were analyzed using Avisoft-SASLab Pro (Version 4.2). The use of two digital cameras enabled the re-creation of flight paths allowing changes in call characteristics to be observed along with changes in the position of group members relative to each other. I then compared the signals to those produced by echolocating bats. To date, the data suggest that chimney swifts, like bats, produce individual signatures and may produce synchronous or asynchronous calls depending on circumstance.

Thermal Energetics of Female Big Brown Bats

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We investigated thermoregulation and energetics in female big brown bats (*Eptesicus fuscus*) by exposing bats caught in southeastern South Dakota to a range of ambient temperatures (T_a) and used respirometry to record metabolic responses. Bats were typically thermoconforming and almost always entered torpor at T_a below the lower critical temperature (T_{lc}) of 26.7° C. Basal metabolic rate (BMR, 16.98 ± 2.04 ml O_2 h^{-1}, mean body mass = 15.0 ± 1.4 g) and torpid metabolic rate (TMR, 0.460 ± 0.207 ml O_2 h^{-1}, mean body mass = 14.7 ± 1.3 g) were similar to values reported for other vespertilionid bats of similar size and similar to a value for BMR for *E. fuscus* calculated from published data for bats from North Carolina. However, we found that bats had a lower T_{lc} (by at least 6° C), and lower thermal conductance at low T_a, relative to big brown bats from North Carolina. All but two bats entered torpor as soon as T_a dropped below about 27° C and, once in torpor, bats rarely aroused even though many of the resting metabolic rate (RMR) recordings were done during the active phase. During torpor, the minimum individual basal temperature (T_b) we recorded was 1.1° C and bats began defending minimum T_b at T_a of approximately 0° C. Minimum energy expenditure during torpor was as low as 2% of BMR. BMR was 76% of that predicted for bats on the basis of body mass. Overall, the Vespertilionidae have been under-represented in previous analyses of the relationship between BMR and body mass in bats. Our data, combined with data for other vespertilionids, suggest that the family may be characterized by a lower BMR than that predicted based on data from other groups of bats. The propensity for big browns to use torpor in the lab, and the large energy savings that accrue, are consistent with results from the field, highlighting the important role of torpor for balancing the daily energy budgets of bats and the evolution of energy conserving physiological traits in these animals.

Variation in the Stable Isotope Values of Indiana (*Myotis sodalis*) and Little Brown Bats (*M. lucifugus*): Implications for Examination of Migratory Pathways

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The Indiana bat (*Myotis sodalis*) is an endangered species and despite many conservation efforts, has continued to decline in some areas. Effective conservation efforts will require a thorough understanding of the entire ecology of the species. Although some bat species migrate long distances, very little is known about the migratory patterns of most bat species, including the Indiana bat. Stable isotope analysis is increasingly being used to address questions on animal migration. This project was designed to test the applicability of stable isotope analysis for examining migration of bats in the eastern United States. Hair was collected from Indiana bats and little brown bats (*Myotis lucifugus*) captured throughout the eastern United States during summer 2004. Hair samples were analyzed for stable hydrogen isotope ratios using standard, accepted laboratory methods and differences due to geographic location, sex, age, and species were analyzed using ANOVA and ANCOVA. Hydrogen isotope ratios varied significantly among geographic areas with a significant negative relationship occurring between latitude and hydrogen isotope ratios, but sex and age did not have a significant effect on isotope ratios. The relationship between latitude and isotope ratios for Indiana and little brown bats had similar slopes but the *y*-intercepts were significantly different from each other. Differences in isotope values between species from the same geographic areas were unexpected for such closely related species. Overall, our results indicate the potential power of using hydrogen stable isotope ratios to understand the migratory patterns of Indiana bats as well as other species.

Acoustic Survey in Arizona Sky Islands of the Madrean Archipelago

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In the summer of 2005 we conducted monthly acoustic surveys for bats in six mountain ranges contained within the Madrean Archipelago of southeastern Arizona. The Arizona ‘Sky Islands’ provide habitat for many high elevation terrestrial species that could not otherwise survive in the surrounding desert or grassland landscapes. These mountain islands of the Madrean Archipelago also provide corridors that link the highlands of the Sierra Madre Occidental to the American Rocky Mountains and, as a result, these mountain ecosystems represent incredible biodiversity. We sampled the ultrasonic calls of foraging bats using passive Anabat detectors (frequency division) with storage capable ZCAIMs in waterproof protection at remote sites, plus active sampling using both the portable AnaPocket setup and the Pettersson D240x (time-expansion) bat detector to simultaneously record bat calls. Use of the two detector systems to sample the same bat call allows us to exploit the strengths of both systems to better identify species. We will discuss species diversity and activity patterns by foraging bats along mountain riparian corridors and in high mountain meadows. These data will provide resource managers with better insight into which bat species are using the Sky Islands of southeastern Arizona.

The Historical Biogeography of *Dobsonia* (Chiroptera: Pteropodidae) in Australasia

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The distribution of the approximately 13 species of *Dobsonia* covers one of the most interesting and complicated of the world's biogeographic regions, Australasia. At previous NASBR meetings, I have presented an evolutionary phylogeny of the genus *Dobsonia* constructed from *cytochrome b* sequences. The phylogenetic relationships among populations and species reveal the evolution of differences in body size, tooth morphology, roost-site preference, and colony size. Though biotic factors may be invoked to explain much of the evolution of these morphologically and behaviorally distinct species, some of the evolutionary and geographic patterns are not so easily understood. However, no story of evolution is complete without including the region's geographic history. The incredibly dynamic geography of this region has played a central role in the evolution of *Dobsonia*. In this paper I will present the most recent geologic reconstructions of Wallacea, Micro- and Meganesia, and explain how that history has influenced the evolution and diversification of *Dobsonia* species. This example illustrates the importance of the time axis — the timing of both geologic and phylogenetic events — in evolutionary studies, and the need for movement away from static models of island size and isolation to explain current biological distributions.

The Effect of Tourist Visits on Behavior of *Rousettus madagascariensis* in the Caves of Ankarana, Northern Madagascar

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Disturbance of bats in their day roosts represents a potentially important threat to the conservation of these mammals. The effect of cave tourist visits on bats, however, especially on pteropodids in tropical systems, remains poorly understood. This work assessed the effect of tourist visits on behavior of the Malagasy endemic *Rousettus madagascariensis* (Chiroptera: Pteropodidae) in the Ankarana Special Reserve, northern Madagascar. Using experimental visit treatments, we studied the effect on bat behavior of tourist proximity and level of illumination. By recording bat response to low-intensity visits in both regularly-visited colonies and unvisited colonies, we also sought support for the hypothesis that bats that are regularly visited are habituated to some types of tourist visits. Preliminary results suggest that proximity and illumination during tourist visits affect behavior of bats, and that the response of regularly-visited colonies differs from that of unvisited colonies. The results of this study contribute to understanding of bat behavior and may help managers direct ecotourism activities at Ankarana and at other cave tourism sites.

Studies on the Natural History, Population Ecology, and Landscape Genetics of Rafinesque's Big-eared Bat in Southeastern Virginia

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We located a colony of Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) in an abandoned one-room schoolhouse near the town of Yale, Sussex County, Virginia. The colony expressed a high level of fidelity to this roost, until Hurricane Isabelle made landfall in southeast Virginia in 2003. The hurricane caused moderate damage to the structure, including partial destruction of the roof. The colony of bats vacated the site following these damages and only returned (in much lower numbers) during the spring of 2005. Subsequent to this documented return, the roof of the structure was repaired and the building was restored to pre-hurricane condition. We are currently studying their response to these structural repairs. Additionally, we are using a programmatic approach to study the natural history and landscape ecology of this colony. We are studying micro-climatic roosting conditions, social behaviors, diet, foraging activities, bioaccumulation of environmental toxins, colony-level molecular ecology, and landscape genetics of this colony. This presentation will summarize and discuss our findings to date.

Ecological Correlates of Home Range Size Variation in the Tent-making Bat, *Artibeus watsoni*

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In this study, we examine foraging and roosting range size variation in the tent-making bat, *Artibeus watsoni*, and determine the relative importance of site, sex, age, reproductive status, habitat, season, and population density on movement patterns in this species. We radio-tracked a total of 42 individuals at two sites in the Golfito Wildlife Refuge and six sites at Corcovado National Park, southwestern Costa Rica, and found that the home range of *A. watsoni* is the smallest recorded for a bat species (3.64 ha). A multivariate test to evaluate the importance of all seven factors on ranging patterns confirmed that all, except sex and population density, had a significant effect on foraging ranges. Bats living in more productive sites, such as primary forests, had smaller foraging ranges, and subadults ranged farther than adults. In addition, adult satellite males had the largest range among males, perhaps resulting from a roaming strategy to secure mating opportunities. Females in late pregnancy during the dry season had the smallest foraging ranges of all, most likely as a result of flight constraints imposed by the large fetus and an increase in fruit availability, and lactating females sampled during the early rainy season, which have large energetic requirements, had one of the largest foraging ranges. Additionally, all factors except age had a significant effect on roosting ranges, and bats in areas of abundant roosting resources, such as primary forests, had the largest ranges of all. Males had significantly smaller roosting ranges than females, which may be attributed to the defense of tents by males, and the differences in roosting ranges among satellite and resident males may be explained largely by resource abundance, because satellite males inhabit areas of extremely low roost abundance, and as a result use smaller areas than resident males. Lactating females had the smallest roosting ranges of all, probably resulting from energetic constraints imposed by the relocation of juveniles at night to alternate roosts. Finally, bats sampled in areas of low population density had significantly smaller roosting areas, most likely in response to competition for limited roosting resources. These results confirm that energetic requirements, along with foraging and roosting resource abundance and distribution, are largely responsible for determining ranging patterns in *A. watsoni*. However, the effect of each factor on the movement patterns of this bat must not be considered independently from one another, since significant interaction terms were observed in our analyses.

Genetic Evidence for Population Structure in the Little Brown Bat, *Myotis lucifugus*

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Like many temperate bat species, *Myotis lucifugus* lives in groups during some parts of the year while at other times individuals disperse. These variations are partly based on sex-biased dispersals and may provide an opportunity for gene flow not seen in species living in restricted ranges or harems. I used microsatellite DNA markers to investigate the gene flow and population dynamics of the little brown bat (n = 167), considering nursery colony, swarming, and hibernating populations from a wide geographic area (20–360 km between sites). During the summer months, I found significant genetic differentiation between geographically separated populations. Within colony relatedness estimates for maternity colonies, although low (R = 0.03 to 0.1), are significantly different than zero, indicating that maternity roosts are composed of related individuals. In the late summer and early fall, swarming populations are genetically distinct but have a low relatedness estimate. In the winter, hibernation sites represent a very mixed population with no observed structure. The data support previous observations suggesting that mating is random. There are microgeographical patterns of genetic isolation by distance within the population and gene flow occurs from extra colonial copulation at swarming and hibernation sites. Combining these data with evidence from tag recovery studies, I suggest that patterns of population structure will be found across the species' range and that the patterns change with the seasons as the behavior of the bats varies. I propose that the availability of hibernation sites is a limiting factor in population dispersal and isolation.

Foraging Patterns and Roosting Sites for Female Big Free-tailed Bats (*Nyctinomops macrotis*) in Northern Arizona

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We attached radio-transmitters to eight female big free-tailed bats (*Nyctinomops macrotis*) captured at six different sites throughout northern Arizona, June–August 2005. We tracked bats for a cumulative total of 13 days to identify foraging patterns, roost locations, and travel corridors. Tagged bats kept their transmitters for approximately only two days. One bat was tracked for seven nights and spent almost all of its time foraging over Great Basin desertscrub vegetation and on one occasion made a 1-h round trip flight into ponderosa pine forest, an elevation gain of 1077 m. Great Basin desertscrub and various tributaries to the Colorado River were used extensively as foraging areas and travel corridors. Total distance traveled nightly was estimated as ~32 km for each of two bats. Roost sites were in cracks and crevices in sandstone in the upper portions of vertical cliffs along the upper Colorado River (Marble Canyon), Kanab Creek (Grama Canyon), and Canyon de Chelly. Of the seven bats tracked back to roost sites, three were found to be roosting in the same location in Marble Canyon and two other bats were found to be roosting in the same location at Canyon de Chelly. An exit count conducted at the Canyon de Chelly roost confirmed at least four bats exiting, suggesting big free-tailed bats form small maternity colonies, which is consistent with the literature. We were unable to document night roosting for big free-tailed bats. Bats emerged from day roosts ~20:30 each night, foraged for approximately six hours, and returned to their day roost. Previous work in the southwestern United States with big free-tailed bats indicated similar roost sites; however, information regarding foraging patterns is absent from the literature. Big free-tailed bats appear to be patchily distributed in northern Arizona and use similar habitat compared with other populations in Utah, New Mexico, Texas, and Mexico.

Factors Affecting the Spatio-temporal Activity Patterns of Eastern Pipistrelles (*Pipistrellus subflavus*) over a Large Spatial Scale in Southwest Nova Scotia and an Assessment of the Value of Monitoring this Species for Detecting Landscape Change

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Understanding the factors that affect spatio-temporal activity patterns of species is essential for developing effective conservation and management plans for species and ecosystems. Current data suggest that, in Nova Scotia, the population of eastern pipistrelles is small, distinct (behaviorally and morphologically), and disjunct from conspecific populations and thus has the potential to be a significant population. The objectives of this research were to: 1) determine the regional distribution of the population; 2) quantify the affects of landscape and site-level factors on species activity; and 3) assess the value of a systematic eastern pipistrelle acoustic survey program to monitor the biological integrity of landscapes (or particular landscape elements). From June–August 2005 we acoustically sampled each of 40 river sites in southwest Nova Scotia three times, with each survey lasting three nights. Through a modeling exercise, we are determining the quantitative effects of site and/or landscape level variables, how phenology and weather affect activity levels, and quantifying their effects. We predict that eastern pipistrelle activity will be positively associated with the area of rivers and lakes for foraging and the area of mature spruce stands for roosting within commuting distance of the sites. If our predictions are supported, such a survey protocol will be useful for indicating changes in forest dynamics at the landscape level with a decrease in activity indicating a loss of landscape elements associated with eastern pipistrelles (e.g., mature softwood stands with conditions appropriate for the growth and persistence of *Usnea* spp. lichens).

Kootenay Community Bat Project: A Community Approach to Bat Inventory and Conservation

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The Kootenay Community Bat Project was initiated in 2004 as a community approach to bat inventory and conservation. This project, located in southeastern British Columbia, promotes education and awareness of bats, identifies bat roost sites (particularly on private land), and assists landowners with roost conservation planning. Extension activities include press releases, bat-house building workshops, interpretive programs, and public mist netting nights. Residents are encouraged to report bats so that biologists can visit the roost sites, identify species present, and discuss and address their issues. Additionally, they provide strategies to conserve and enhance roosts, and encourage residents to conduct long-term monitoring of bat populations on their property. In 2005, the first Annual Backyard Bat Count was initiated. During the past two summers (of 15 field days each season), over 150 roost sites (including 86 maternity roosts) have been identified for six species of bats, including *Myotis californicus*, *M. evotis*, *M. lucifugus*, *M. yumanensis*, *M. volans*, *Eptesicus fuscus*, and *Corynorhinus townsendii*. Colony sizes ranged from single bats to more than 1000 individuals. Fifty-seven percent of the roosts hosted maternity colonies. All roost sites occurred within anthropogenic structures. Two of these roost sites were maternity colonies for the Provincially-listed Townsend's big-eared bat (*C. townsendii*), including one of the largest known colonies in the region and a unique colony living within a resident's living room with frequent disturbances. One of the greatest values of this project is the education and awareness component that is integral to each of the project activities. As a result of this project, more residents are conserving bats and their roosts, and collecting unique and valuable data that contribute to the understanding and conservation of local bat species.

Foraging Site Selection of Mediterranean Bats in Olive Groves and Native Woodlands

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Olive groves are an important foraging habitat for several species of bats in the Mediterranean, where there has been a long history of human impact on habitats. But from a bat's standpoint, olive groves and forests may not be significantly different habitats. To determine the relative importance of different types of olive grove management to bats, and their suitability as foraging habitat for 'forest' bats, I recorded bat activity (passes per minute) and foraging activity (feeding buzzes per minute) in four habitat types: organic olive groves (n = 6), non-organic olive groves (n = 6), Mediterranean oak forest (n = 3) and pine forest (n = 3). Sites were 4 km from the others of the same type, to minimize pseudoreplication, and each site was sampled on three separate nights. Recording began at sunset and continued for 2 h, using Avisoft RECORDER-USG, and I analyzed calls using Avisoft SASLab (Avisoft Bioelectronics, Berlin). Bat activity was highest in organic olive groves, followed by oak forest (*Quercus ilex* and *Q. cocciferra*), mixed pine and oak forest (*Pinus halepensis* with *Q. cocciferra* undergrowth), and non-organic olive groves. Whenever possible, I identified the calls to species to determine whether foraging bats foraged in all available habitats.

Combining Phylogenetic and Coalescent Approaches to Resolve the Recent Evolutionary History of North American Long-eared *Myotis* Species (Vespertilionidae)

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Recent molecular systematic research on North American long-eared *Myotis* species (*M. auriculus*, *M. evotis*, *M. keenii*, *M. milleri*, *M. septentrionalis*, and *M. thysanodes*) demonstrates that this group is made up of two lineages that have converged towards similar morphologies and ecologies. *Myotis auriculus* and *M. septentrionalis* are somewhat distantly related to the remaining species. However, patterns of mitochondrial genetic variation among the four western long-eared *Myotis* species (*M. evotis*, *M. keenii*, *M. thysanodes*, and *M. milleri*) are inconsistent with current taxonomy and are characterized by extensive geographic variation. A combination of phylogenetic and coalescent approaches is used on the extensive mitochondrial dataset currently available to test hypotheses concerning the recent evolution of this unique group.

Feeding Behavior, Bite Force, and Ecology of the Wrinkle-Faced Bat, *Centurio senex*

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Centurio senex is best known for its bizarrely naked, wrinkled face and the exaggerated chin lappet of the males. Underneath that striking visage is also one of the most derived skulls seen among mammals. A member of the Stenodermatinae, *Centurio* is generally considered to be a specialized frugivore. Until now, almost nothing was known about its feeding behavior or the maximum bite forces it can produce. Here we present feeding behavior, bite force, and feeding ecology data collected in September of 2004 during fieldwork in Campeche, Mexico. Perhaps not surprisingly, the feeding behavior of *Centurio* is unique among bats that have been studied thus far. *Centurio* uses unilateral bites almost exclusively when feeding on both soft and hard fruits. Unilateral biting is common among stenodermatines, but no other species employs that biting strategy to such a large extent. *Centurio* also uses a unique side-to-side twisting motion when detaching a mouthful of fruit. Other species that use head movement during feeding employ an antero-posterior pulling motion. Bite force in bats increases from anterior to posterior bite points except for a distinct drop in bite force during unilateral canine biting. We found that unilateral canine biting is not weak in *Centurio* as well as two other small-bodied stenodermatines. These bats exhibit a steady increase in bite force as bite points shift posteriorly along the toothrow. We propose several hypotheses regarding the potential relationship between this unique pattern of bite force production, feeding behavior and cranial morphology. In addition to the behavioral data we collected from *Centurio*, the field site provided insights into the diet and perhaps the migratory habits of this enigmatic species.

Metabolism and Arousal Patterns in Hibernating Eastern Red Bats (*Lasiurus borealis*)
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Many bats use torpor to conserve energy during daily or seasonal periods of inactivity. Seasonal torpor (hibernation) allows bats to avoid thermoregulatory costs of extreme conditions. Unlike other temperate hibernating bats, eastern red bats (*Lasiurus borealis*) do not utilize the typical hibernacula (e.g., caves). Instead, *L. borealis* move into leaf litter during cold bouts of winter months. Because temperatures fluctuate widely at these winter roosts, our first goal was to determine whether there was a correlation between winter arousals and ambient temperature (T_a). Additionally, we measured changes in metabolism and body temperature (T_b) during hibernation and arousals at various T_a. Using these data, we estimated winter energy budgets within selected temperature profiles. Bats were captured during fall of 2003 and 2004 in southwestern Missouri and kept in environmental chambers simulating natural conditions. We assessed torpor durations using temperature-sensitive data-loggers within environmental chambers maintained at 2, 5, 10 and 15° C. Metabolism during torpor (MR_t; measured as oxygen consumption rates) was assessed within metabolic chambers maintained at -5, 1, 5, 10 and 15° C. These data were evaluated for differences between gender and T_a. Our data suggest that torpor bout duration was not affected by gender and it was negatively correlated with T_a. Likewise, MR_t was not affected by gender but it did vary with T_a. T_b of hibernating bats approximated T_a and the difference between these temperatures was greatest at 1° C.

The Effects of Various Temperatures on the Successful Hibernation of Indiana Bats
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Indiana bats (*Myotis sodalis*) are listed as federally endangered due to their dramatic decline in numbers, possibly reflecting increased cave temperatures where they hibernate. These increases cause bats to deplete more stored energy during winter months; bats use more energy to maintain their torpid state and arousal may occur more frequently. If energy stores are depleted, bats may be unable to reproduce in the spring due to poor body condition, or ultimately, not survive winter. Knowing the temperature range that provides the greatest success for hibernation (minimal metabolic rates) may contribute to conservation efforts of this endangered species. Preliminary work focused on the relationship between metabolic rates and ambient temperature. Indiana bats were obtained from Great Scott Cave in Sullivan, Missouri (Washington County) in early November. These bats (n = 4) were maintained in an environmental chamber that mimicked "cave" conditions of 4–6° C and 85+% humidity. Bats were placed into metabolic chambers that indirectly measured metabolism by measuring oxygen consumption, and tested at various temperatures (1, 5, 8, and 22° C). Preliminary data suggest a narrow temperature range that includes 5° C to be ideal for Indiana bat hibernation. Future studies will address metabolic rates at additional temperatures around 5° C, and arousal frequencies at the same ambient temperatures.

Life During Bat Time: A Poetic Salute to Radiotelemetry (with Apologies to Talking Heads)

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Bat radiotelemetry is a strenuous undertaking, requiring long overnight hours and strenuous hiking in difficult terrain and occasionally hazardous situations. Due to these conditions and the accompanying lack of sleep, a certain mindset often emerges wherein safety and data collection are taken seriously, but most other things are not.

Mother-Infant Communication in the Big Brown Bat (*Eptesicus fuscus*)

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The first vocalizations that infant big brown bats produce develop into several types of calls. Many of these calls serve to communicate with their mothers. During spring and summer *Eptesicus fuscus* form large maternity colonies consisting of as many as 100 females and their pups. If the pups are separated from their mothers, they can locate each other using olfaction and vocalizations. The goal of our study was to characterize the spectrotemporal structure of the communication calls used in these mother-pup interactions and to determine how these calls are used when mother and pup become separated. Three pregnant females were removed from a captive breeding colony maintained at the University of Washington. Each female gave birth to two pups (one male and one female). Calls were then recorded from these six captive born pups. Recordings were made in a sound-attenuating chamber (Industrial Acoustics Co., Inc.) using BatSound Pro version 3.3 (Petterson Elektronic, Inc.). We recorded the vocalizations of the pups from postnatal day one to postnatal day forty-two. This allowed us to categorize and describe call structure and distribution of call types throughout development. We compared the vocalizations emitted by each pup when it was alone (separated from both mother and sibling) to vocalizations emitted when the mother was introduced. Calls emitted by pups when they were alone developed into highly stereotyped rapid downward FM sweeps similar to adult echolocation calls. As young bats matured, the spectrotemporal structure of the calls changed. The maximum and minimum frequencies increased as the overall duration decreased. Calls recorded from pups when the mother was introduced resembled communication calls of adults and mother-pup communication calls of other species. Calls emitted by the young bats in the presence of their mother were characterized by a downward FM sweep followed by a tail that varied in structure. In general, these calls had lower minimum and maximum frequencies, longer durations, and more variation in number of syllables than the calls that were emitted by the pup when it was alone. During mother-infant interaction, the mother also emitted communication calls in response to her pup's calls. It is possible that these function as directive calls that facilitate acoustic learning in the pup. Our data suggest that vocalizations play an important role in mother-infant communication and that big brown bats may use vocal signatures in these calls to find each other in large groups.

Understanding the Echolocation Calls of Bats: Location, Location, Location

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The goal of our study was to assess the variability in the echolocation calls of bats. One aspect involved determining the impact of microphone location on our perceptions of what echolocating bats say. To this end we deployed an array of four microphones, three at the same level laid out in an equilateral triangle 7 m on each side, with the fourth 3 m above the apex of the triangle. Then we recorded free-flying bats in the field and analyzed recordings from each microphone. In Costa Rica, in 120 minutes we detected 39 feeding buzzes at all four microphones (21 emballonurid, 18 vespertilionid), but only 3 on all four microphones (7 on three microphones, 9 on two, 20 on one). There were significant differences between microphones in the values for call parameters [duration, frequency with maximum energy, high frequency (-5 dB from frequency with most energy, and -10 dB) and low frequency (-5 and -10 dB)]. Comparable approaches in southwestern Ontario and on the big island in Hawaii with *Lasiurus cinereus* revealed the same impact of microphone location on call features. On the big island in Hawaii, we also recorded echolocation calls entirely unlike those previously reported for *Lasiurus cinereus semotus*, suggesting the presence of another species of bat there. We conclude that when you are recording bat calls, location matters.

Genetic Differentiation within West Indian *Erophylla* with Comparisons with *Phyllonycteris* and *Brachyphylla* (Phyllostomidae)

Theodore H. Fleming, Kevin L. Murray, and Patricia Esquivel, University of Miami, Coral Gables, FL

The phyllostomid bat fauna of the Greater Antilles contains two currently recognized endemic subfamilies — Phyllonycterinae (with two genera, *Erophylla* and *Phyllonycteris*) and Brachyphyllinae (with one genus, *Brachyphylla*); each of these genera contains two extant species. As part of a study of the phylogeography of *Erophylla* and two other phyllostomid lineages, we have studied the systematic status of the two species of *Erophylla* (*E. sezekorni* and *E. bombifrons*) using DNA sequence data from the mitochondrial control region and *cytochrome-b* gene as well as published morphological data. The overall phylogeographic structure of *Erophylla* includes two well-supported clades in the Greater Antilles: an eastern clade occurring on Hispaniola and Puerto Rico (*E. bombifrons*) and a western clade occurring on Jamaica, the Caymans, the Bahamas, and by inference, Cuba (*E. sezekorni*). The *cytochrome-b* genetic distance between these two clades, however, averages 1.8% (range: 1.2–2.2%). This value corresponds to the median value for intraspecific variation within several species of phyllostomid bats and murid rodents and is less than most values for pairs of sister species within these bats and rodents. Depending on which morphological characters are chosen for study, the two clades are morphologically distinct or not in principal components analyses. Our tentative conclusion is that these clades have only recently (within the last 1 Ma) become isolated and have not yet differentiated into separate species. The lack of strong genetic differentiation within *Erophylla*, which last shared a common ancestor with its sister genus *Phyllonycteris* about 7 Ma, contrasts strikingly with that within *Phyllonycteris* and *Brachyphylla*. We discuss the

implications of these genetic data for understanding the evolution of endemic bats in the West Indies

Temporal Patterns of Body Surface Temperature and Spatial Distribution in Roosting Brazilian Free-tailed Bats, *Tadarida brasiliensis*

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Efficient use of energy for flight and roosting activity is essential to the survival and reproductive success of bats. Energy required to maintain a physiologically appropriate body temperature (T_b) throughout the day plays an important role in the efficiency of this energy balance. Clustering is an adaptive thermoregulatory behavior used by bats and other small animals to increase energy conservation. This study describes changes in clustering behavior of free-ranging Brazilian free-tailed bats (*Tadarida brasiliensis*) over a time scale of 24 hours. To investigate these changes, we used a FLIR Systems Thermacam S65 infrared thermal camera to record images of roosting bats at a maternity colony in Ney Cave, Bandera, Texas. The position of roosting bats made it possible to record their behavior from outside the cave. With a telephoto lens, we were able to determine body surface temperatures of roosting bats without direct contact and without interfering with their normal activities. Our observations indicate reduced clustering behavior immediately following the return of bats from foraging, presumably to facilitate heat dissipation, and more compact cluster formation as the day progressed to presumably enhance energy conservation. This preliminary study further illustrates the utility of infrared thermography and helps explain the intricacies of clustering as an adaptive behavior.

Age-specific Consumption Ability in Little Brown Bats (*Myotis lucifugus*)

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Several studies show that adult and subadult insectivorous bats eat different types of insects. This may reflect differential food handling abilities between adults and subadults. To test this, I captured 20 adult and 20 subadult little brown bats (*Myotis lucifugus*) outside of roosts and swarming sites in southern Ontario, Canada, and fed them hard and soft food items. I videoed each bat while it was eating, and used frame-by-frame analysis to watch the sequence of events as the bat consumed each food item. Preliminary results suggest that a greater proportion of subadults were unable to consume hard food items readily eaten by adults, and that young that could eat harder foods took significantly longer than the adults to do so.

Fasting in the Common Vampire Bat: An Evaluation of the Physiological Parameters Associated with their Metabolic Fragility

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Previous studies from our laboratory have demonstrated the metabolic fragility of common vampire bats (*Desmodus rotundus*) when submitted to fasting. Preliminary results have showed a small content of body energy reserves (low content of liver glycogen, no fat depots) in fed bats. As a consequence, after only 24 h of fasting, vampires experience a drastic fall in blood glucose, also due to their inability to mobilize proteins from muscle tissues. Therefore, some of the known mechanisms associated with the maintenance of glucose homeostasis seem to fail during fasting in vampires, leading to early deaths after only 2–3 nights of fasting. This study was designed to investigate physiological processes that might be associated to this particular fasting condition. For this purpose, we analyzed the activity of the gluconeogenic enzyme P-enolpyruvate carboxykinase (PEPCK) in cytosolic and mitochondrial liver fractions, plasma insulin levels from fed and 24 h-fasted bats, and *in vitro* insulin secretion from incubated pancreas fragments. Insulin secretion was determined in four different incubation medium containing: (1) 2.8 mmol glucose/L; (2) 16.7 mmol glucose/L; (3) 2.8 mmol glucose/L + 10.0 mmol leucin/L; (4) mmol glucose/L + 2.0 mmol glutamine/L. Data were analyzed by one-way ANOVA followed by the Tukey test. The results showed that *D. rotundus* present PEPCK activity in both cytosolic and mitochondrial liver compartments. However, fed vampires were found to have higher enzyme activity in the cytosol (50.32 ± 3.65 nmol/mg prot/min) rather than in the mitochondrial fraction (12.87 ± 2.06 nmol/mg prot/min). In response to 24-h fasting, PEPCK activity increased only in the cytosol (179.27 ± 13.44 nmol/mg prot/min). Plasma insulin levels in fed vampires (0.81 ± 0.22 ng/mL) was 60% lower than in rats, and decreased significantly in vampires after fasting (0.34 ± 0.11 ng/mL). Insulin released after 1 hour incubation of vampire pancreas showed no significant differences in medium 1, 2, 3 and 4, unlike all mammals previously tested, which show a marked increase in insulin release in medium 2, 3 and 4 compared to 1. Taken together, our results suggest that high PEPCK activities found in both fed and fasted vampires seem unrelated to the increased liver gluconeogenesis usually found in animals fed high protein diets. Instead, it may be associated with lower plasma insulin levels and decreased insulin secretion observed in vampire pancreas. Lower concentrations of insulin might also explain lower body energy reserves found in *D. rotundus*. Furthermore, decreased energy reserves and poor activation of liver gluconeogenesis might be determinant factors contributing to the drastic fall of blood glucose following 24 h of fasting in common vampire bats, and also to the subsequent premature deaths reported in the literature. Financial support: CNPq, FAPESP.

Fission-Fusion Sociality in the Northern Long-eared Bat, *Myotis septentrionalis*

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Socioecological theory predicts that social systems evolve as a result of selection for social behaviors adaptive to the ecological constraints in an animal's environment. Consequently, temporal variation in the magnitude of these ecological constraints may lead to variation in the

fitness costs and benefits associated with conforming to a particular social system. Increasingly, studies are suggesting that fission-fusion sociality, a flexible social system where community members have the option to join temporary groups of varying composition and size, may be a common social system among bat species. It is this flexibility that may be of particular importance to bats allowing for the immediate adjustment of roosting group size and composition in relation to environmental and ecological variation. In this study we will 1) assess whether female *Myotis septentrionalis* roost preferentially with certain individuals more often than would be expected if roost mates were selected at random; 2) describe the temporal patterns of association among individuals; and 3) model pair forming in relation to reproductive status and environmental constraints. Fieldwork is being conducted in Dollar Lake Provincial Park, Nova Scotia, Canada. Bats are monitored via radiotelemetry and PIT-tag (passively integrated transponder) recorders at roosts. To date (9 Aug.) we have captured 41 females and located 54 roost trees within a 4.2 km^2 roosting area. We have located 27 of these individuals on three or more occasions with an average of nine re-sightings per bat. Initial analysis suggests that this community conforms to the fission-fusion social model with individuals forming several distinct roosting sub-groups between which some movement of individuals occurs. Roosting ranges of these sub-groups appear to overlap extensively.

Higher-level Megabat Phylogeny: Results from Combined Analyses of an Expanded Morphological Dataset with New and Old Mitochondrial and Nuclear Sequences

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The systematics of Megachiroptera was established in the early 20th century by Knud Andersen. His classification remained the major reference on megabat relationships until recently, when molecular results rejected most traditional megabat groupings, and new clades were supported. However, combined analyses have shown that the conflict between the most recent morphology-based, non-cladistic classification of megabats and the molecular evidence is less significant than previously thought. Currently, available data include a fragmentary representation of sequences from four mitochondrial and one nuclear gene from previous authors, and our morphological matrix of 236 characters from many different organ systems. As part of an ongoing effort to increase the available data, we sequenced three nuclear genes (*RAG1*, *RAG2*, and *vWF*), the subject of a separate presentation. Here we show the results of a combined analysis that includes the five previously available genes, the three new nuclear genes, and an expanded and modified morphological matrix. This character-congruence approach, by which all characters are co-optimized and most parsimonious solutions are preferred, is used to test some of the current hypotheses of megabat relationships. In this talk we deal with the interaction of the heterogeneous data sources in producing the higher-level pattern of relationships recovered, and how the perceived relationships potentially affect the current classification of megabats.

Intraspecific Variation in the Echolocation Calls of Brazilian Free-tailed Bats, *Tadarida brasiliensis*

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Some studies have demonstrated variation in echolocation calls among different geographic populations of the same species, although other studies have not. Within the United States, Brazilian free-tailed bats are currently divided into two subspecies, *Tadarida brasiliensis cynocephala* in the Southeast and *T. b. mexicana* in the West, and in the past these groups have been recognized as separate species. Their recognition was originally based on behavioral differences between the taxa, including roosting habitat, colony size, and migratory tendency. However, genetic data show no geographic structure and indicate the two groups share a common gene pool throughout North America. Echolocation is an important sensory process in bats that will be shaped by both local ecology and evolutionary patterns of population genetic structure. The objective of this study was to determine if geographic variation exists in the echolocation calls of Brazilian free-tailed bats and to interpret these findings in reference to known behavioral and genetic patterns of the two subspecies. Echolocation calls were collected from known, light-tagged individuals at 16 sites throughout the range of *Tadarida brasiliensis* in the United States. Although significant differences in call structure exist between populations of *T. b. cynocephala* and *T. b. mexicana*, no geographic trend was found across sites. Carlsbad Caverns National Park in New Mexico was a notable outlier in the dataset. Calls at this location were similar in duration and bandwidth to those collected at other sites, but were higher in frequency. Preliminary observations indicated this frequency change might be an adjustment to avoid local interference from high frequency insect noise that was not present at other locations. To test this hypothesis, we performed a playback study in which we broadcast insect noise at varying frequencies to free-flying *T. b. mexicana* in South Central Texas. Results indicate that bats are shifting their echolocation calls to avoid spectral overlap with this high intensity, ultrasonic insect noise.

***Big Brown Bat Ultrasonic Signals Differ when Used for Echolocation versus Mating**

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***Matthew Grilliot** received the **Speleobooks Award**

Investigating the communicative function of ultrasonic signals in a social context provides valuable insight into one of the most sophisticated communication mechanisms utilized by any species. In many animal species, ultrasonic signals are used in intraspecific and interspecific communication for a variety of social purposes. Bats are well known for their use of ultrasound for navigation and foraging. However, few studies examine bat ultrasound in a social context, and none conclusively demonstrate a role for ultrasonic communication in bat 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 differences in ultrasonic signals used for courtship and mating and those used for echolocation. In the reproductive season, we recorded the echolocation signals of 20 adult male and 20 adult female big brown bats on tether lines in the field. We compared these signals to previously collected data of ultrasonic signals used in courtship and mating. We show that the ultrasonic emissions of big brown bats are sexually dimorphic when used for courtship and mating, but not when used for echolocation. This provides evidence for the role of ultrasonic communication in courtship and mating behaviors in the big brown bat.

Ground Roosting Ecology of the Western Long-eared Myotis (*Myotis evotis*) in Southern Alberta

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The western long-eared myotis (*Myotis evotis*) is a widely distributed species that roosts in a variety of structures. Throughout its range in western North America, *M. evotis* roosts in live trees, dead or dying trees, tree stumps, houses, caves, and boulders. In the arid badlands of southern Alberta, *M. evotis* almost exclusively roosts in the ground. I tracked 33 individual *M. evotis* to 143 ground roosts during the summers of 2004 and 2005. Ground roosts were always in erosion holes or under rocks in the ground, and almost exclusively on south-facing exposures. Roost characteristics, thermal profiles of roosts, and frequency of roost switching will be presented and discussed in the context of sex and reproductive status of marked bats.

Diversity of Echolocation and Foraging Behavior of Mormoopid Bats in an Evolutionary Context

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Echolocation is a key ecological feature for insectivorous bats. Different echolocation systems allow bats to use different microhabitats and prey. Spectral and temporal parameters of calls may seem very flexible from the vocal and mechanical point of view. However, neural processing structures may not be so plastic, perhaps requiring major evolutionary transitions to extract information qualitatively different from echoes. In that respect, echolocation systems may not be so plastic in the evolutionary history. In this scenario, historical relationships among echolocation systems may have influenced decisively the structure of contemporary bat faunas. Characteristics of the echolocation system are commonly fixed at the family level, although some families show great interspecific diversity in the echolocation calls. This is the case of mormoopid bats. Because this family has few members, and the evolutionary relationships among them are well known, it seems a good model to study evolution of bat echolocation. It has been used for testing some hypotheses about evolution of echolocation. Specifically, the echolocation system used by some species, based on short-CF+FM signals, has been hypothesized as intermediate between systems based on broadband or narrow frequency analysis of signals. Also, a non-Darwinian, 'hopeful-monster'-like evolutionary origin of the narrow frequency analysis system found in *Pteronotus parnellii* has been proposed. Knowledge about the ecological context where the peculiar echolocation signals of mormoopids are used is fundamental for the evolutionary interpretation of changes in signal structure. However, it remains obscure for most species. We have collected information about the echolocation and foraging behavior of the mormoopids living in Mexico, by using infrared video synchronized with ultrasound recording, and light tagging. We find that the diversity in the structure of echolocation calls is correlated with an amazing diversity in foraging behavior. One species is an understory forager, another an aerial insectivore in background cluttered spaces, another trawls for insects on water surfaces, and another is a high altitude aerial hawker. All species include constant frequency elements in their signals, but they use them in different ways. When we put the information on echolocation behavior on a phylogenetic framework, we find evidence for the presence of narrow frequency analysis in the ancestor of the Mormoopidae. On the other side, the most recently diversified species of the *Pteronotus* subgenus and the island forms of the *Chilonycteris* subgenus seem to have lost the capability of narrow frequency analysis, although puzzlingly preserving a short constant frequency element in the call.

Comparison of Bat Use at Water Catchments in Iron County, Utah
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Eight water catchments located in Iron County, Utah were surveyed for bat use during the late summer and fall of 2004 and the spring of 2005. We compared use of three types of water catchments: guzzler, ring tank, and earthen stock pond. Survey data were collected through the use of digital video, Anabat acoustic recordings, and mist net captures. Comparison of bat behavior at each water type was recorded using night vision digital video camcorders. Acoustic recordings were used to detect relative bat abundance and species composition in areas regardless of actual water catchments use. Mist net traps were used to confirm species presence, age, and sex of bats using the water catchments. Water catchments size and shape as well as water quality appeared to affect bat use. Catchments designed primarily for sage grouse or antelope were not used by bats. This may be due to limited surface area of water and the shape of the drinking trough. Amount and type of aquatic vegetation also affected bat use. Those water sources with thick surface algal blooms appeared to be unusable as a drinking source but may be used as an insect feeding area by bats. Preliminary analysis suggests that earthen stock ponds are used most by bats, followed by large cattle ring tanks. Additionally, few bats were found near any of the antelope or sage grouse guzzlers that we monitored.

The Development of Long-duration Acoustic Bat Detectors for Southeast Alaska
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A new acoustic sensor for long-duration (~100 days) observations of bats is being developed. A low-power computer-based system has been developed. The system will be described, with particular focus on the tradeoffs between power consumption, processing power, and scientific and monitoring needs that drove the system design. Long-duration monitoring of several different types of areas (such as old-growth versus recently logged forest) will provide knowledge to improve management practices in regards to bat ecology in Southeast Alaska. The role of long-duration acoustic monitoring will be described. [Work supported by Alaska Department of Fish & Game.]

Winter Bat Activity and Roost-site Selection in Managed Forests in the Lower Coastal Plain of South Carolina

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Research examining the roosting and foraging behavior of North American bat species primarily occurs from May to August. Management decisions affecting bat populations are often based upon the information collected from these studies. Although important, data gathered during the summer season do not provide a complete assessment of the habitat requirements necessary for bats year-round. Winter studies previously conducted have focused on cavern or building roosting bats. Information concerning forest bat ecology in winter is limited. We began a study in December 2003 to examine the winter activity and roost-site selection of forest bats in the Lower Coastal Plain, South Carolina. Anabat detectors and temperature recording devices were placed in various forested habitats as well as next to ponds to assess bat activity. Bats were more active on warmer nights, and activity decreased with decreasing temperature. Radio-transmitters were secured to three evening (*Nycticeius humeralis*), one red (*Lasiurus borealis*) and twelve Seminole (*L. seminolus*) bats. Evening bats used day-roosts similar to those used in summer. However, Seminole bats roosted in dramatically different structures. Winter roost-sites of Seminole and red bats included overstory hardwood trees, pine needle clusters hanging from understory trees, and leaf litter on the forest floor. Knowledge gained from this study will provide vital information useful in developing management guidelines that encourage year-round bat presence and minimize adverse impacts within managed forests.

The Distribution of the Forest-dependent Northern Long-eared Bat, (*Myotis septentrionalis*) Relative to Forest Patch Size, Composition, and Context

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Understanding the quantitative effects of fragmentation of forests is key to understanding the response of populations of forest-dependent species. The structure and composition of the forests of Prince Edward Island (PEI) was altered dramatically with the arrival of European settlers, resulting in a dramatic loss of forest cover and an isolation of remnant patches. Currently, over much of the island, agriculture forms the matrix within which there are some forest patches, a complete reversal of what would have been expected in historic times. The northern long-eared bat, *Myotis septentrionalis*, is a forest interior specialist that exclusively uses the forest interior for both foraging and roosting. The objective of this study is to determine the quantitative relationship between fragment characteristics (local and landscape level) and the probability that northern long-eared bats will use the fragment. Trapping surveys were conducted in forest fragments using harp traps on two different nights and where possible, at two different sites, during the summer of 2005 to determine whether northern long-eared bats were present. As of early August, 37 northern long-eared bats were captured as evidence of presence in 17 of 62 surveyed forest fragments, including two reproductive females. Analysis will involve a model selection procedure with multimodel inference.

Preliminary Assessment of the Summer Distribution of the Indiana bat *Myotis sodalis* in New York

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Knowing the summer distribution of Indiana bats that originate from specific hibernacula is important for both local and range wide reasons. It is a preliminary step in understanding why numbers in hibernacula in many southern areas are in decline while those in northern regions, including NY are generally increasing. It is crucial in evaluating the risks associated with the ever increasing number of wind farm developments across the species range. Beginning in 2001, New York State Department of Environmental Conservation (DEC) staff have coordinated a multi-agency effort to use aircraft to radio-track Indiana bats as they migrated from/to their summer range. This method eliminated many of the sampling biases associated with mist netting surveys. Three hibernacula containing roughly 85% of New York's winter population were sampled on five occasions. We released 95 bats with radio-transmitters attached: 4 males, 21 females that were not checked for reproductive condition, and 70 reproductive females. Seventy-one animals (75%) were detected at least once at a day roost. Sixty-seven (70%) were detected more than twice at roosts and we retained contact with them for the expected life of the transmitters. Of the 24 not found on a roost, 6 did not leave the release site in time to be tracked, and at least 6 others were detected, but we did not try to follow them. The highest exit counts at roosts of 70 bats with transmitters ranged from 0 to 98 animals; 42 high counts included two or more bats. Animals with transmitters were not detected beyond 60 km from their hibernaculum although we searched as far as 117 km in some cases. Only three were within 10 km, and all three were from the same hibernacula. Over 80% of roost sites were less than 180 meters in elevation and were typically in patches of hardwood forest associated with agricultural lands or low-density residential development. Given the random nature of the sampling, the high recovery rate, and the likelihood that some of the missing animals were overlooked within the search areas, we feel that these results probably reflect the summer distribution of the species at these study areas.

Roosting Ecology of the Townsend's Big-eared Bat (*Corynorhinus townsendii*) in the West Kootenay Region of Southeastern British Columbia, Canada

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Southern British Columbia, Canada, constitutes the northern extent of the Townsend's big-eared bat's (*Corynorhinus townsendii*) range in North America. In 2003, a conservation initiative was implemented in the West Kootenay region of British Columbia to fill information gaps regarding the distribution and roosting ecology of the species. Prior to this research, Townsend's big-eared bats had only been documented roosting in three locations within the project area. Species distribution was determined through mist netting and visual inspections of abandoned mines, buildings, and natural caves. Mist netting at night roosts (abandoned mines and caves) was undertaken to radio-tag reproductively active females to identify maternity roost locations. Radio-tagged females (n=13) were tracked from fixed wing aircraft because of the rugged mountainous topography within the project area. To date, Townsend's big-eared bats have been documented roosting in 56 new locations (25 natural rock features, 16 abandoned mines, and 15 buildings). Maternity roosts were located in three natural rock features and one building. Cold season surveys have been limited; however, Townsend's big-eared bats were located hibernating in two of the three abandoned mines sampled. All roosts occurred in either the dry warm or very dry warm subzones of the Interior Cedar-Hemlock Biogeoclimatic zone. As a result of the project, several conservation recommendations are being developed. Strategies include working with the Ministry of Mines to develop a protocol that incorporates the needs of Townsend's big-eared bats into plans for mine entrance closures and providing recommendations to modify current provincial forest practices legislation to provide adequate protection for maternity colonies occurring in natural rock features.

Roost Switching and Association Patterns in the Foliage-roosting Bat (*Myotis formosus*) in Taiwan

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Roost switching and association patterns of foliage-roosting bats, *Myotis formosus*, were investigated in the south-western plain in Taiwan. Female *M. formosus* usually roost in groups during the breeding season. In total, 79 *M. formosus*, including different sexes, ages, and reproductive status, were marked individually during May to August, 2005. Marked bats were located and censused visually and daily in the study area. In addition, 13 adult females and 1 adult male were radio-tagged and their day roosts were located. Preliminary results show that bats belonging to different reproductive status or roost types showed different frequencies of roost switching. Bats often stayed in a small roosting area even when roost switching occurred. In addition, bats not only switched roosts individually, but sometimes the whole group switched to the next roosting site together. Details about association patterns among group members will also be discussed.

***Myotis septentrionalis*: A Katydid Predator.**

Hannah ter Hofstede and James Fullard, University of Toronto at Mississauga, ON

Katydids (Tettigoniidae) are well known for their loud calling songs, produced by males to attract females. These conspicuous signals are easy to localize, which means they are excellent for mate attraction, but also risky due to eavesdropping predators such as gleaning bats. *Neoconocephalus ensiger*, a katydid found throughout North-eastern North America, demonstrates song pausing and cessation when exposed to ultrasound while singing. We conducted fieldwork at the Queen's University Biology Station (QUBS) during July and August 2005 to determine the culprit (bat species) exerting selection pressure on these katydids, and to gain information on cues used by this predator to locate prey. *Myotis septentrionalis*, a gleaner, became the prime suspect. In a large outdoor flight enclosure, wild-caught *M. septentrionalis* readily landed on a speaker broadcasting the calling song of *N. ensiger* and attacked live individuals singing in grass. We investigated differences between subadult and adult bats (response to sounds), prey-handling behavior and echolocation call features while hunting in the enclosure. Future work will explore the sensory sensitivity of *N. ensiger* to gleaning attacks of known intensity using neurophysiological methods and include comparisons with other local katydid species.

Bats and Angel Rings: Quantifying Flight Behavior and Population Dynamics with NEXRAD Doppler RADAR Images

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In 1957, the U.S. government developed the first national network of RADAR systems for the purpose of weather surveillance. Shortly thereafter, RADAR operators began observing echoes on their video displays that did not move or behave like weather patterns, including expanding ring-like shapes they called angel rings. The echoes were high-flying insects, migrating birds, and large colonies of bats emerging from their roosts to feed. Modern WSR-88D Doppler weather RADAR stations now provide detailed images of bat emergences and flight behavior of groups of bats. The large cave and bridge colonies of Brazilian free-tailed bats (*Tadarida brasiliensis*) in south-central Texas are clearly imaged by three local WRD88-D Doppler RADAR stations. In this study, we used Doppler RADAR reflectivity and radial velocity images to examine colony size, direction of movement, speed of dispersion, and altitude gradients of bats from these colonies during the hours after evening emergence. Base reflectivity clear-air mode level II NEXRAD images were geo-referenced and compiled in a GIS along with colony locations and landscape features. Temporal sequences of images were masked at selected colony locations, and spatial means and total reflectivity were calculated. These measures, combined with data from radial velocity images, were used to compute directional vectors and compare emergence behavior using circular statistical models. Relative colony size and inter-annual changes were also measured. Our results indicate that multiple factors play a role in the nightly flight and dispersal behavior, and that NEXRAD imagery can be a useful tool for censusing and monitoring large bat populations. Understanding the distribution of a large regional bat population on a landscape scale has important implications for agricultural pest management and conservation efforts.

What Have We Been Talking about for the Past Thirty-five Years?

G. Roy Horst, *Emeritus* NASBR Member and Director; *Emeritus* Editor, *Bat Research News*, Potsdam, NY

The Annual North American Symposium on Bat Research is now in its 35th annual meeting. These symposia have been attended by the majority of bat biologists in North America who over the years have presented more than 2,500 reports of the results of their research. To date over 1,000 individual biologists have attended and 600 established researchers, students, and interested amateurs have given presentations. Over the years, the principal areas of interest included biogeography, echolocation, ecology, genetics, physiology, and systematics. As interests evolved and new techniques became available, the areas receiving the most attention have changed considerably. The most profound change has been the improvements in technology and how it has altered the approaches taken in our research and increased the sophistication of our investigations. In this presentation titles have been arranged in each of several major categories for each five-year period during our history and some of these categories are presented in graphic form to facilitate comparisons of the relative and changing attention given each of the subject areas over the past thirty-five years. Space forbids inclusion of all the categories represented in these symposia, but for comparison the general topics of Behavior, Echolocation, and Phylogeny are included. Ecology, physiology, and morphology have always been major areas of interest but the variety of approaches in these categories are so diverse as to defy easy comparisons. Not surprisingly, nearly all genera in Chiroptera are represented. It is interesting to see what directions our research efforts have taken during these three-plus decades, but it is difficult to draw any meaningful predictions as to what directions our members will follow in the near or distant future as individuals retire and new workers join the membership of biologists interested in Chiroptera. The continuing increase in numbers of individuals involved in bat biology bodes well for the future of bat research everywhere.

Seasonal Monitoring of Brazilian Free-tailed Bats at Carlsbad Caverns National Park Using Advanced Infrared Thermal Imaging

Nickolay Hristov, Margrit Betke, and Thomas H. Kunz, Boston University, Boston, MA

The Brazilian free-tailed bat (*Tadarida brasiliensis*) is a widespread species in the southwestern United Stated between March and October, where it typically forms large aggregations in caves, buildings and bridges. A major colony of this species is present at Carlsbad Caverns National Park, New Mexico. The nightly emergence of hundreds of thousands of bats from this cave has been a principle attraction for visitors of the park for more than 70 years. Because of its educational, aesthetic, and scientific value, numerous attempts have been made since the 1920s to estimate the size of this colony. Roost accessibility, cave topography, variable roosting densities, and nocturnal behavior, however, have made colony estimates difficult, often resulting in highly variable results. Recorded differences in colony size may reflect natural patterns of behavior, disturbances from anthropogenic factors, or different and/or inaccurate census methods. Nevertheless, previous reports indicate a general decline in colony size. Notable declines in this colony are of concern to visitors and resource managers at the park, as well as to the local business community. Understanding the ecological and economic importance of this species requires reliable estimates of numbers and composition of the colony. The goal of this project is to provide accurate and reliable seasonal colony estimates of the Brazilian free-tailed bats at the cave using advanced infrared thermal imaging. Bat emergences were monitored monthly as bats emerged at dusk, using high-performance thermal cameras between August and October in 2004 and March and October in 2005. Recordings of nightly emergence were analyzed using adaptive visual recognition algorithms that account automatically for the identification and tracking of individual bats. In addition, infrared thermal cameras were set up inside the cave to monitor the activity of bats throughout the night. We present the first accurate estimates of the number of Brazilian free-tailed bats at Carlsbad Caverns. Our results indicate large fluctuation in the size of the colony on a seasonal as well as daily basis. Some of these fluctuations reflect seasonal migratory habits of these bats, but others may be linked to large-scale seasonal weather patterns and related insect availability. These results will be discussed in the context of developing quantitative-based management plans and for the protection of these bats as an important national resource.

The Echolocation Behavior of Davy's Naked-backed Bat, *Pteronotus davyi* (Chiroptera: Mormoopidae)

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Mormoopid bats show great interspecific diversity in the structure of echolocation calls. Some bats in the family, such as *Pteronotus davyi*, broadcast signals composed of short-CF and FM elements, and may represent intermediate evolutionary steps between sonar systems based on FM pulses adapted to forage in open areas, and those based on long CF signals adapted to forage in within-forest cluttered areas. We studied the echolocation behavior of *P. davyi* in open versus background clutter situations, and during approach to prey, trying to infer function of the components of the signals. When foraging in open areas, rate of emission of search phase signals was 16.5/s. Pulses were composed of an initial short CF segment (71.96 kHz, 2.01 ms), followed by an FM segment with linear modulation of period versus time (PLM), 4.10 ms long on average, ending in a quasi-constant tail (QCF, final frequency: FFIN = 59.37 kHz; n = 7 sequences, 136 pulses). Bats that were foraging near background, broadcasted search phase signals with similar repetition rate (16.4/s), CF (72.09 kHz), and FFIN (58.72 kHz). However, the CF segment was slightly longer (2.19 ms), and the PLM element shorter (3.39 ms). During approach to flying prey, the repetition rate increased progressively, but duration of pulses decreased, mostly due to the shortening of the PLM element. The CF and FFIN were almost constant during the approach phase. The bandwidth was consequently kept almost constant and the modulation rate of the FM element increased progressively. Duration of the CF element was constant during most of the approach phase, and later decreased slowly. Variation in the structure of the PLM element between open and cluttered situations, and during approach to prey, is similar to what has been observed in bats using pure PLM signals. These changes are the result of a trade-off between long-range detection and increased resolution, and serve to avoid pulse-echo overlap. The presence of a short CF element above the frequency range of the PLM element is a characteristic that *P. davyi* shares with bats performing narrow frequency analysis. The bats might use the CF element to obtain information about fluttering prey. However, collateral data indicate that *P. davyi* does not perform Doppler shift compensation and has no acoustic fovea. As an alternative hypothesis, the bats could be using the CF segment to measure speed, or that the segment could be a rudiment of the signal used by the ancestor of all *Pteronotus* spp., potentially a narrow frequency analysis echolocator.

Kinematics of Turning Maneuvering in the Lesser Short-nosed Fruit Bat (*Cynopterus brachyotis*)

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For flying organisms, it is critical to be able to make sharp and controlled turns, particularly when they need to actively pursue prey and/or move effectively in complex, three-dimensional environments. It has been widely assumed that turning ability is related to wing shape, where short, wide wings are better suited to maneuver because of reduced wing loading. This prediction is derived from classic theory that models maneuvering in bats as that of fixed-wing aircraft. Bat flight, however, is spatially and temporally complex, and bat wings dynamically change shape during upstroke and downstroke, and this limits the degree to which students of bat

flight can apply aircraft aerodynamics. Because of our inadequate knowledge of wing and body movements during turning, it is almost impossible to predict where and when aerodynamic forces are going to be applied to produce changes in position and flight direction. Moreover, turning can be achieved in several ways. The fundamental mechanism of turning is an asymmetry of force generated by the left versus right wing, but this asymmetry can be produced by differences in the timing of the wingbeat cycle, by asymmetry in wing position and/or shape, or both. Thus, detailed descriptions of wing and body kinematics during turns are required to comprehend how wing shape and motion relate to turning performance. The purpose of this study is to describe the kinematics of turning during slow flight in the lesser short-nosed fruit bat (*Cynopterus brachyotis*) to investigate the mechanisms involved in its maneuvering. Four individuals were trained to fly in an L-shaped flight enclosure that required a 90-degree turn midway through each flight. We placed ultra light-weight reflective markers on the body and both wings. Turning flights were recorded at 500 images per second with three high-speed, low-light digital video cameras, and data from the three cameras were combined to reconstruct 3D motions of each marker. When the bats flew relatively slowly (2–4 m/s), the movements of the wing were spatially complex. Change in heading (yaw) angle occurs primarily during the upstroke. Change in flight direction occurs during the beginning of the downstroke. The change in heading angle is related to a differential folding of the wings during upstroke. This pattern suggests that inertial forces during upstroke induce a reorientation of the major axis of the body, followed by thrust generation by the downstroke, which stabilizes the heading angle and finally changes flight direction.

Thermal Profiles of Abandoned Mines in Alaska: Implications for Use by Bats

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Little is known about the association of bats with abandoned mines in Alaska, and it is largely supposed that subterranean habitat will not generally provide critical roosting habitat for bats. In this study we conducted internal surveys of seven abandoned mines on the Chugach National Forest looking for direct evidence of occupancy by bats. Additionally we installed data-loggers throughout all surveyed mines and generated internal thermal profiles. Data-loggers were programmed to collect temperature data every 30 minutes from August 2003 – August 2004. Thermal profiles were then used to infer potential roosting habitat offered by each of the surveyed sites. Variation in climatic conditions was determined through standard descriptive statistics and internal conditions were compared with ambient temperatures to determine the degree of thermal buffering offered by each mine. Humidity was recorded at, or near, 100% inside all of the mines, so relative humidity data for mine interiors were not used to infer climatic profiles. All of the mines surveyed during this project were cold and wet with average summer temperatures of 46° F. These cool, wet conditions are likely most conducive to hibernation and/or summer bachelor use. None of the mines included temperatures of sufficient warmth for use by maternity colonies. No bats were observed during the surveys, but evidence of night roosting activities was found in one of the mines (Case Mine). It is most likely that little brown bats (*Myotis lucifugus*) utilize abandoned mines in Chugach National Forest during winter hibernation and bachelor males and mixed-sexed groups probably use the mines as night roosts during the summer.

Habitat Use of the Mariana Flying Fox (*Pteropus mariannus mariannus*) on Guam (U.S.A.)
Dustin S. Janeke, University of Guam, Mangilao, GU

Flying foxes of the genus *Pteropus* (Pteropodidae) are largely insular in distribution, with 96% of species having a range including or restricted to islands. Insular flying foxes are vulnerable to a wide range of natural and anthropogenic impacts, including typhoons, volcanic eruptions, over-harvest, habitat loss and degradation, and predation by introduced species. Nowhere are these impacts more evident than on the western Pacific island of Guam, where the effects of war, introduced ungulates and brown tree snakes (*Boiga irregularis*), military and civilian development, and over-hunting, have left the Mariana flying fox (*Pteropus mariannus mariannus*) struggling to survive. Despite a ban on hunting since 1973, and local and federal endangered status being assigned in the early 1980s, *P. m. mariannus* have declined on Guam from 1000 bats in 1982, to less than 100 bats in 2005. An understanding of how this species makes use of its habitat will aid efforts by resource managers to develop effective recovery strategies and mitigate impacts from development projects. Radiotelemetry was used to study the nocturnal movements of bats on Andersen Air Force Base in northern Guam. Four bats, three of which were selected for radio collaring, were captured in 13 nights of netting. Individual bat movements were recorded for one to seven months, and analyses identified six foraging areas that bats used. Vegetation in each of these areas was sampled to determine forest composition. Each bat used a different day roost site and had distinct foraging patterns. Two bats regularly foraged in highly disturbed secondary forest areas. Activity patterns of all three bats indicated a tolerance of current military activities, including small arms, explosive ordinance, construction, and an active runway. Observations of bats foraging in disturbed areas that have high densities of the introduced shrub *Cestrum diurnum* (Solanaceae) suggested a factor that may contribute to the lack of flying fox recovery, as the bats eat *Cestrum* fruits, which are known to cause calcinosis and atropine-like poisoning in other mammals.

Foraging Behavior of the Long-legged Myotis (*Myotis volans*) in Northern Idaho
Joseph S. Johnson, Michael J. Lacki, and Michael D. Baker, University of Kentucky, Lexington, KY

Effective conservation of bat populations in the commercial forests of the northwest United States will rely on accurate knowledge of their habitat requirements. Data on how foraging behavior and habitat use of bats changes throughout the year will help forest managers identify habitat components necessary to protect the continued existence of forest-dwelling bats. Limited data are available on the foraging behavior of the long-legged myotis (*Myotis volans*), a species of concern throughout much of its distribution. To evaluate patterns in use of home range among bats of different reproductive conditions, we captured and radio-tagged 35 long-legged myotis during the summers of 2004 and 2005 in north-central Idaho. Females were identified as pregnant ($n = 12$), non-pregnant ($n = 3$), or lactating ($n = 9$), and reproductive and non-reproductive males were grouped together ($n = 11$). Radio-tagged bats were tracked to their day roosts and movements of bats triangulated using multiple detection stations throughout two study watersheds. Home range size was calculated for any bat with ≥ 40 locations, and habitat use of bats analyzed by determining the percent area of each home range occupied by available habitats in the watersheds (i.e., upland forest, mid-slope forest, clearcut forest, riparian forest). Bats roosted up to 5.8 km from where they were observed foraging. Home range size ranged from 0.2 km^2 to 31.5 km^2 for males, 0.6 km^2 to 25.1 km^2 for non-pregnant females, 1.1 km^2 to 9.8 km^2 for pregnant females, and 0.58km^2 to 2.3km^2 for lactating females. These data indicate that reproductively active, adult female long-legged myotis use a smaller home range, especially in lactation, than non-reproductively active females. Data on use of available habitats will be presented.

Differences in Swimming Styles in Bats

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Because different bat species, particularly those from different families, have evolved different flying styles, we predicted that different bat species also swim differently. Using a high speed camera taking images at 1/250 per sec, we photographed pallid bats (*Antrozous pallidus*), big brown bats (*Eptesicus fuscus*), Yuma myotis (*Myotis yumanensis*), and Mexican free-tailed bats (*Tadarida brasiliensis*) to determine swimming speed, buoyancy of body in water, ratio of wing area used during swimming to the total wing area, and swimming style. Additionally, we determined hair density and weighed the masses of bats before and after swims to determine the amount of water absorbed in fur. Swimming speeds of bats were similar between species, but buoyancy of body in water, ratio of wing area for swimming/total wing area, swimming style, hair density, and the relative amount of water absorbed by fur, varied among species. Earlier observations on swimming (*Noctilio leporinus*, *Pteronotus personatus*, and *Lasiurus ega*) also suggest different swimming styles and anatomy associated with swimming.

Physical Abnormalities in a Population of Free-ranging Bats

Tiffany Jones and Allen Kurta, Eastern Michigan University, Ypsilanti, MI

Between 1995 and 2004, 5296 free-ranging bats were examined at Tippy Dam, Manistee Co., Michigan, to determine the frequency of physical abnormalities in a wild population. Most bats (94%) were little brown bats (*Myotis lucifugus*), and the most common abnormality was squared-ears, which occurred in about 1% of the population. Contrary to a preliminary study in Missouri, my data indicated that the frequency of the trait did not differ between the sexes and that it occasionally occurred in only one ear as opposed to both. Other abnormalities that were seen included abnormalities of the tragus, asymmetrical pinnae, and malformed feet/digits.

Preliminary Assessment of Land-use and -cover Change near Indiana Bat Hibernacula

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Understanding the connectivity between summer and winter populations of migratory threatened and endangered bats is essential for successful management and recovery. Summer maternity colonies of the federally endangered Indiana bat (*Myotis sodalis*) have been documented on a number of army installations and potentially occur on many others.

Unfortunately, little is known about associations between Indiana bat maternity and hibernating populations, including those that utilize maternity habitat on army installations. Impacts on Indiana bat survival during migration, swarming, hibernation, and staging can have important consequences for the viability of maternity populations found on army installations. For example, reductions in the amount or quality of foraging or roosting habitat near hibernacula caused by timber harvest, urbanization, water quality degradation, stream channelization, and large-scale use of pesticides could negatively affect Indiana bats during fall swarming and spring staging, and/or affect cave microclimate. Although forest management restrictions on public lands may benefit Indiana bat recovery where they are imposed, many hibernacula are not protected within the borders of large public landholdings. The extent to which these hibernacula may be threatened by urbanization or other land-use and -cover change (LUCC) has not been previously investigated. Without any information on the current condition or level of protection afforded to relevant hibernacula, the effectiveness of army investment in Indiana bat monitoring, management, and training mitigation is potentially compromised. We have initiated research to: 1) design and test a PIT tag reader gate that will allow non-invasive, re-sighting of marked bats at hibernacula; 2) use the reader gate to identify the hibernation sites of Indiana bats that use maternity habitat on Camp Atterbury and Newport Chemical Depot (both of which are in Indiana); 3) characterize the current land-use and -cover of the landscapes surrounding these hibernacula; 4) model LUCC through 2010 at these sites; and 5) conduct a similar, range-wide assessment of the current and future threat of urbanization and land-use change near Indiana bat hibernacula. Our characterization and modeling efforts will focus on variables that describe biophysical and socioeconomic factors relevant for Indiana bat conservation and projecting rates of LUCC (e.g., land-use and -cover, human population size, topography, hydrography, etc.). These characterizations and projections will allow us to generate discussion and consciousness about the current status of land use and cover near Indiana bat hibernacula, as well as the potential threats caused by LUCC near winter hibernacula. This poster will present a summary of the approach and some preliminary analyses.

Information Content of Sonar Calls of Little Brown Bats, *Myotis lucifugus*: Potential for Communication

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The purpose of this research is to examine variability in sonar calls related to characteristics of the bat producing the calls. If variation in call features can reliably indicate characteristics of a bat (e.g., colony membership, gender, age category, reproductive condition, or individual identity), then there is potential for sonar calls to transfer this information to conspecifics. Thus, sonar calls, in addition to their use in navigation and prey capture for many bat species, may function in communication. We obtained recordings of sonar calls from 66 little brown bats (*Myotis lucifugus*) captured from buildings at Chautauqua Institution in Chautauqua, NY, the SUNY Fredonia campus, and surrounding areas over the summers of 2003, 2004, and 2005. Colony membership, gender, age category (adult or young of year), reproductive condition of females (lactating or not lactating), and weight of each bat was determined. Sonar recordings were obtained while allowing the bat to crawl from hand to hand. The recording system included a laptop computer, digitizing card (up to 500 kHz sampling rate), connector box, amplifier, and U30 bat detector used as a microphone. Sonar calls were extracted from the original recording files and analyzed using custom computer programs written in MATLAB. After sonar call analysis, several variables that describe each call were obtained and were used for statistical analysis. We will report on variability in the sonar calls related to the characteristics of the bat producing the calls within each year as well as a combined analysis for all three years. Analysis of calls from 2003 and 2004 suggests several bat characteristics are reliably indicated by sonar call variation, allowing for the potential use of sonar for communication in little brown bats.

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

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Every summer in south Texas, millions of Brazilian free-tailed bats (*Tadarida brasiliensis*) consume large numbers of insects that are agricultural pests on important economic crops. To these large populations of bats, industrial agriculture in this region serves as an enormous insectary, producing billions of moths that include corn earworms or cotton bollworms (*Helicoverpa zea*), fall armyworms (*Spodoptera frugiperda*), cabbage loopers, (*Trichoplusia ni*), beet armyworms (*Spodoptera exigua*), and tobacco budworms (*Heliothis virescens*). However, in the ten years since their first use, Bt (*Bacillus thuringiensis*) crops have become widespread in the region. We are investigating the influence of Bt crops, which can kill up to 95% of target pests, on bat activity in the Winter Garden agricultural region of south Texas. Twelve Anabat II detectors were deployed in replicate Bt and conventional corn and cotton crops. Crop fields were monitored as insects emerged from fruiting corn and dispersed to nearby cotton. Numbers of echolocation passes and feeding buzzes are compared between Bt and conventional fields for both crop types over multiple nights. This study will contribute information on the ecological consequences of genetically modified crops and their possible effects for the conservation of extremely large bat populations that have undergone significant declines. To our knowledge, this is the first study investigating non-target effects of Bt crops on mammalian insectivores.

A Comparison of Changes in Wing Loading Associated with Pregnancy in *Myotis evotis* and *Myotis lucifugus*

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Bats inhabit and forage in a wide variety of habitats. Where and how various species of bats forage is related to wing loading, which varies with juvenile growth and development and also with state of gestation in adult females. During gestation increases in mass may affect the use of certain habitats and dietary composition. We compared how wing loading changed during pregnancy between two species of bats, *Myotis lucifugus*, an open-area forager, and *M. evotis*, a clutter-area forager. Bats were captured using mist nets over water holes. The right wing of each individual was extended onto a piece of graph paper that included a metric scale (mm) and was photographed with a digital camera mounted on a tripod. Images of wing profiles were loaded into Sigma Scan Measurement Software to obtain wing area measurements. Wing area was divided into mass to determine the wing loading for each individual. Individuals of each species were categorized as pregnant or non-pregnant depending on reproductive state determined by abdominal palpation. One-way ANOVA was used to test for significant differences between wing loading for pregnant and non-pregnant females of each species. Multiple regression analysis was used to plot changes in wing loading throughout the months of May to September for each species. Results showed no significant differences in wing loading between pregnant and non-pregnant *M. evotis* ($p = 0.86$), whereas significant differences in wing loading did occur between pregnant and non-pregnant *M. lucifugus* ($p = 0.04$). Multiple regression analyses were not significant for pregnant *M. lucifugus* females by week ($r^2 = 0.04$, $p = 0.29$) nor for non-pregnant females by week ($r^2 = 0.43$, $p = 0.40$). This result was expected because of small sample sizes. A significant regression was found for pregnant *M. evotis* ($r^2 = 0.299$, $p = 0.02$), whereas none occurred for non-pregnant females ($r^2 = 0.15$, $p = 0.96$). With further data collection we predict significant regression line equations will result as a predictive model of wing loading changes associated with pregnancy in these species.

Patterns of Association in Forest-dwelling Female Big Brown Bats (*Eptesicus fuscus*)

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In the Cypress Hills of Saskatchewan, Canada, telemetry data was used to provide evidence in favor of the "fission-fusion" model as an explanation for how roosting individuals of a colony congregate and segregate over time in different roosts. I used subcutaneous transponders in combination with telemetry to document roosting associations by *Eptesicus fuscus* in the same study area. Transponders provided data on roosting for a greater number of individuals and for longer periods of time than telemetry alone and provided additional data on changing association patterns that telemetry alone likely could not. The simple ratio index was used as a measure of frequency of association. Observed dyadic index values were compared to expected values generated from null models of association using a modified Monte Carlo permutation procedure. Adult females roosted together significantly more often than expected by chance, although adults in dyads with highly significant associations did not always roost together. Groups switched roosts frequently (mean ± SD = 3.3 ± 3.4 days) using 35 known day roosts. Overall patterns of association for adult dyads changed over the sampling period and were significantly different in each of three reproductive periods (pregnancy, lactation, and post-lactation). There were a greater number of positive associations highly significantly different than random in the pregnancy period than in the lactation or post-lactation periods. The frequency of significant positive associations was also greater in the lactation period than in the post-lactation period where dyadic associations more closely resembled those expected by chance, although strongly significant positive associations were still present. Mean index values formed by dyads of non-reproductive individuals differed significantly from those of reproductive female dyads. My results also support the fission-fusion model and provide some evidence that constraints associated with rearing young may affect the social cohesion of roosting groups.

Bat House Success and Use at the Arizona-Sonora Desert Museum in Tucson, Arizona

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Arizona is home to 28 species of bats. In recent years the desert southwest has suffered a rapid increase in land conversion that has eliminated much of the traditional roosting and foraging habitat of bats. The Arizona-Sonora Desert Museum (ASDM) grounds have specific habitat conditions favorable to bat house occupancy, such as open water, vegetational diversity, "nuisance" colonies of bats, natural roosts for transitory and night roosts, and documented species of bats that will utilize bat houses. Little is known about bat house occupancy in the desert southwest. In the spring of 2002, ASDM and Bat Conservation International tested 33 bat houses for bat preference and utilization. The bat houses were constructed and installed at various sites on the ADSM grounds and a data-logger was placed in each house to record temperature. The houses vary in shape, size, and color. More than half of the bat houses have been occupied by three species of bats (*Eptesicus fuscus*, *Myotis velifer*, *Tadarida brasiliensis*). All three of the bat species have used the houses as maternity roosts in the summer months. In 2004, *T. brasiliensis* occupied the bat houses throughout the winter. Bats have occupied houses of varying shape, size, and color. Temperatures inside the bat houses appear to be the limiting factor for bat house utilization at ASDM. The bat house project at ASDM has been successful and illustrates that bats will use bat houses under certain conditions in the desert southwest.

Non-flight Use of Wings by Bats

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Wings are used primarily for powered flight and gliding by birds and bats, but their highly modified forelimbs also serve other functions. In this paper, we identify and review functions of wings of bats that are not directly associated with either powered or gliding flight. We have identified at least 22 non-flight uses of wings by bats, most of which are associated with the following activities: adhesion to roost substrates, alloparental care, copulation, courtship display, crypsis, defecation, digging, food capture, food manipulation, gas exchange, grooming, maternal care, ontogeny of flight, parturition, predator defense, protection, quadrupedal locomotion, roost and female defense, roost modification, stretching exercise, swimming, thermoregulation, and urination. Among these, food capture and food handling represent the most diverse forms of modified uses. Many of these non-flight uses of wings reflect similar adaptations of forelimbs by quadrupedal mammals, and appear to be associated mostly with feeding and roosting habits. Although non-flight uses of wings are secondary to powered or gliding flight in bats, constraints imposed by these different uses may have compromised form and function during powered flight in some species.

Histo-pathologies from Prolonged Volcanic Ash Exposure in Bats from Montserrat
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We are reporting pulmonary and renal pathologies in bats associated with prolonged exposure to volcanic ash. The Antillean island of Montserrat has experienced recent violent volcanic eruptions, and the associated volcanic ash and pyroclastic flows have caused various problems for resident mammal populations. Volcanic eruptions, such as those occurring sporadically on Montserrat from 1995 to 2005, are characterized by forceful ejection of a variety of pyroclastic fragments, hot toxic gases, superheated steam, radiation, and lava flows. Ash falls to the ground and remains in the environment for various lengths of time, its removal is dependent on rainfall. Ash fall out includes pulverized lava composed of crystal, glass, and rock fragments, with 90% of fragments less than 10μm in diameter. There have been studies that claim volcanic ash is pathogenic in human populations, causing physical problems, including respiratory problems in children on Montserrat. We previously reported physical signs of non-lethal, stress-related pathologies (dental attrition and alopecia) associated with incidental ash ingestion in endemic bat populations on Montserrat. This study examined gastrointestinal, renal, and pulmonary tissues histologically and histochemically from bats collected on Montserrat and from other Antillean islands. Pathologies found only in Montserrat bats include emphysema, pneumoconiosis, and nephritis. These anomalies associated with chronic volcanic ash fall out have not been previously reported, because other volcanic fall outs have been of short duration and ash has not lingered in the environment as it has on Montserrat.

Mist Netting Bias on Montserrat
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Mist netting is a commonly used and effective method to capture bats. Many investigators have even made crude estimations of bat population size using some variation of the simple “bat captures per net-night (BNN)” metric. Experience has shown, however, that mist net capture data are biased due to a wide range of factors including: wind, precipitation, light-levels, habitat complexity, foraging and commuting behavior, spatial memory, and the plasticity of echolocation behavior employed by bats under different circumstances. We monitored mist net bias on the island of Montserrat (Lesser Antilles) whose simple fauna (ten species: six frugivores, three insectivores, one carnivore) and sample sites are well documented (13 surveys; 1979–2005). Infrared lights (Dalton) were used to illuminate mist nets set across flyways. We used Nightshot camcorders (Sony) to record the interactions between bats and the net at four localities. Although our efforts were interrupted by Hurricane Emily and two eruptions of the Soufriere Hills volcano, we were able to record 1970 bat passes on 25.25 hours of video tape. In the absence of a mist net (control), we recorded an average of 48.95 bats/hour (range 2.7–111.5) along the flyway. In the presence of a mist net, we recorded 85.65 bats/hour (range 10.7–338.7). Circling bats probably account for the increased bats/hour in the presence of the mist net. When a mist net was present, only 83 of the 1713 bats captured on film came into contact with the net (4.8%) and only 53 of these were captured, giving us an average capture rate of 3.1% (range 1.5 –8.0). Those bats that were not captured often circled/reversed direction (54.3%) or flew over the top of the net (37.7%). In addition, inclement weather, volcanic disturbance, and habitat diversity among localities clearly affected our results and subsequent work is clearly needed. However, we did get a first peek into a very complex and interesting aspect of bat biology and mist net bias. These animals are very unique and are far more complex than we may give them credit for.

Winter Bat Activity in the Alberta Prairies

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It has long been hypothesized that bats in the temperate climate of the Alberta prairies move to mountain caves to hibernate for the winter. Using Anabat CF Storage ZCAIM systems powered by solar panels, I monitored the Red Deer River in the Alberta prairies for fall, winter, spring, and summer bat activity. Waves of bat activity were detected in the fall suggesting movement along the river corridors and possible swarming events. I detected bats during every month, including January when temperatures fell below -40° C, suggesting bats hibernate in prairie river valleys rather than moving to mountainous areas. Most winter passes were of *Eptesicus fuscus*, but *Myotis* species were detected in late December and early February. Bats were detected flying in the Red Deer River valley on nights when temperatures remained below 0° C for the entire day. Emergence temperatures were often well below freezing. Temperatures at which bats were active varied, but *Myotis* spp. were detected at temperatures as low as -6° C, and *E. fuscus* at temperatures as low as -8° C. I mist-netted *E. fuscus* throughout February, and radio-tracked both sexes to their rock-crevice roosts. These hibernacula are deep (>3 m) rock cracks and erosion holes with small openings. Preliminary data suggest winter flights may be associated with dehydration. Winter bat activity data collected by these Anabat systems were unexpected, and I suggest that strategic winter placement of solar-powered Anabat/CF Storage ZCAIM systems recording onto high capacity digital memory cards is an excellent way to study hibernation behavior, and uncover where bats are hibernating.

Long-distance Movements of Nevada Populations of the Mexican Free-tailed Bat (*Tadarida brasiliensis mexicana*)

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The Mexican free-tailed bat (*Tadarida brasiliensis mexicana*) occurs throughout Nevada, but there are no published accounts of the seasonal status or movements of populations in this region. Cockrum (1969) hypothesized that *T. b. mexicana* present in Nevada in the summer are part of a distinct group that spends the winter in southern California or northern Baja California. I banded 5862 *T. b. mexicana* at Osceola Cave in east-central Nevada on Aug. 10–11, 1970. Two band recoveries from Las Vegas, NV (300 km south) and one from Yuma, AZ (700 km south) were consistent with fall migration to the lower Colorado River valley. However, a banded female was recovered in northwest Kansas (1250 km east) in May 1971, which may reflect long-distance fall migration to Mexico and subsequent spring movement north through Texas and Oklahoma. At a maternity colony near Fallon in western Nevada, I banded 826 juvenile *T. b. mexicana* on Aug. 10, 1971. From Sept. 1971 through Mar. 1972, there were eight band recoveries from central California, suggesting that at least some members of this population moved over the Sierra Nevada in the fall and spent the winter up to 220 km west in California valley and foothill areas. A recovery at Lake Tahoe (1900 m elevation) on Oct. 11, 1971 suggested a possible migration route. The August 1971 recovery of a bat near Reno, NV that had been banded at Fairfield in central California on Sept. 26, 1969 provided further evidence of interchange between *T. b. mexicana* populations separated by the Sierra Nevada. Although these banding results are based upon a very small number of recoveries, they indicate the potential for gene flow across the entire range of the nominal *T. b. mexicana* subspecies from California to the Great Plains. These field data suggest patterns of long-distance movements that could help to explain the results of recent genetic studies, which have failed to find geographic or population-level structuring within *T. b. mexicana*. There may not be serious inconsistencies between the molecular genetic data and the data from traditional banding studies in this highly vagile taxon.

Optimal Parameters to Attract Bats in California's Central Valley

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In an 8-year study from 1996 to 2004, we evaluated the designs of 186 bat houses intended for use by bats in rural areas of California's Central Valley. The results of our study showed that the attraction of bats to bat houses depended mainly on the location of the houses. Colonies of bats (generally mothers and their young) showed preference for houses that were mounted on structures such as buildings, with shade or morning sun, that were within a quarter mile of water. In contrast, individual bats (generally males and non-reproductive females) preferred houses on poles with full or afternoon sun, with no preference for distance to water. Bat house occupancy was not affected by the size, color, or height of the houses for either individual or colonies of bats. The overall bat house occupancy rate in our study was 76% (48% for colonies and 28% for individuals). Mexican free-tailed bats, *Tadarida brasiliensis*, and *Myotis* sp. bats were most often found using the houses, with the occasional sightings of pallid bats, *Antrozous pallidus*, and big brown bats, *Eptesicus fuscus*.

The Importance of Cenotes in Structuring Bat Communities in Yucatan, Mexico

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Cenotes (from the Mayan word "dzonot") are water sinkholes formed by the dissolution of limestone. In the Yucatan Peninsula, they are the main water sources for plant and animal communities. Our project investigated the importance of cenotes for bats by comparing the community structure between forest and pastureland, with and without cenotes, in order to test the hypothesis that species composition, diversity, abundance and dominance differs significantly between sites and seasons. Five ground mist nets, one canopy mist net, and one harp trap were set at each site. Insectivorous species were also monitored with a Pettersson D980 bat detector and BatSound Pro software (Pettersson Elektronics, Uppsala, Sweden). Community characteristics were analyzed with Species and Richness Software (Pisces Conservation Ltd). After 96 nights of work we caught 2,819 bats from 6 families and 26 species grouped into 6 trophic guilds: aerial insectivore, gleaners, frugivore, nectarivore, sanguivore, and carnivore. Phyllostomids were the most abundant with 17 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 (nonparametric Wilcoxon test). The cenote in pastureland was the most diverse habitat ($H' = 1.47$) but was not significantly different from the others investigated (randomization test at 5% Level). Our results demonstrated that cenotes increase bat diversity and abundance 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.

Nightly Activity Patterns of Bats on Prince of Wales Island, Alaska

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Five species of bats are found in Southeast Alaska. However, little is known about these populations, and bioacoustics may be an effective way to learn more. I used acoustics to study the nightly activity of bats at two riparian areas (Turn Creek and Thorne River) on Prince of Wales Island, Alaska by leaving an Anabat II detector overnight. Three nights of recordings for each site were analyzed for presence of bats, activity patterns, foraging activity, and total activity, using the number of pulses per 10-min period as a measurement of activity. I was not able to distinguish bat passes from each other because of the high density of pulses in the recordings. This suggests an uncommonly large number of bats at these two study sites. No discernable nightly activity pattern was found at either site, and there were differences in activity patterns between sites. The recordings at Turn Creek showed greater concentrations of activity, whereas recordings at Thorne River showed a higher mean level of activity. I found no significant differences in foraging activity or total activity between the two sites. A long-term study is needed to address nightly activity patterns as the shortened periods of darkness in Alaska may cause variations in behavior between Alaskan bat populations and bat populations in the rest of North America.

First Unified Model of Phylogeography and Analysis of Genetic Isolines of *Uroderma bilobatum*

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Geographic Information Systems (GIS) and ecological analysis applied to the study of genetic variation emerge as powerful tools that allow us the analysis of micro- and macroevolutionary patterns simultaneously. Historically, the conceptual gap between micro- and macroevolution has obscured the understanding of important evolutionary processes such as mechanisms of speciation. We introduce the Unified Model of Phylogeography (UPM) and the Analysis of Genetic Isolines (AGI) as new types of analyses that combine micro- and macroevolutionary approaches to understand distribution of lineages across geographic ranges. The UMP is a geographic information system-based model that combines georeferenced quantitative information on biodiversity with georeferenced quantitative information on ecogeographic variation. Information on biodiversity can include a wide variety of data sets such as: genetic distances obtained from DNA sequences, chromosomal numbers, morphometry, and codified discrete characters. Information on ecogeographic variables can be obtained from georeferenced environmental GIS-based layers. Outputs obtained from UMP can be represented as genetic polygon maps, raster layers, and their derived contour lines. The term "genetic isolines" refers to genetic variation represented in the form of contour lines that describe the distribution of genetic distances across ecogeographic landscapes. The UMP allowed us to test the *Uroderma bilobatum* phylogram in a ecogeographic context. Genetic patterns of divergence were highly congruent with the ecogeographic patterns analyzed. Geomorphology explained most of the patterns of genetic divergence among populations of *U. bilobatum*. *Uroderma bilobatum* populations from Venezuela were represented in our model as an isolated lineage with clearly identifiable barriers to gene flow. From an ecogeographic standpoint, specimens from this lineage deserve to be considered a different species, and special taxonomic attention is recommended for this group. The model was powerful in identifying ecogeographic patterns associated with divergence processes in the Neotropics.

Recordings of Spotted Bats (*Euderma maculatum*) Flying up Canyons to a Feeding Area
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Marble Canyon of the Colorado River is a steep-sided slot cut into the surrounding plateau. Many bats roost in the canyon walls and commute to surrounding uplands for feeding. Side canyons that feed into Marble Canyon provide low-angle-of-ascent routes between the river and feeding sites. We recorded spotted bats (*Euderma maculatum*) during late June and early July of 2005 in two such side canyons at locations about 10 km upstream from the Marble Canyon rim. In both canyons, spotted bats began to pass, moving up-canyon, about one hour after sunset and continued to pass for about one hour, after which traffic ceased. The number of spotted bats we observed ranged from 12 to about 60 on four evenings in one canyon, and 18 and 51 bats on two evenings in the other. We used a digital broadband system (sampling rate 455 kHz) to record calls of passing *Euderma* in 30-second blocks, attempting to record all passes. These data provide a description of *Euderma* calls including variation between individuals. The temporal pattern of bat passage may provide insight into roost dispersion and social dynamics of spotted bats. The timing, direction, and abundance of passing *Euderma* suggests that side canyons to the Colorado River serve as major access routes for spotted bats as they fly from their day roosts to feeding areas at higher elevation.

The Use of Fecal DNA to Verify and Quantify the Consumption of Agricultural Pests
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Numerous studies demonstrate that insect-eating bats consume large numbers of agricultural pests. Conventional wisdom not-with-standing, empirical support for the expectation that insect-eating bats can suppress pest populations and protect crops has been elusive from data using conventional dietary analyses based on insect fragments in feces. This is because the digestive processes of bats reduce insects to fragments that typically cannot be identified below Family or

Order, and quantification even at these taxonomic levels is, at best, imprecise. Species-specific DNA sequences of insects that are amplified by polymerase chain reaction (PCR) from the feces of bats can provide species-level verification of insects eaten. We document this approach for four noctuid moth crop pests [Lepidoptera; Noctuidae: *Helicoverpa zea* (corn earworms), *Heliothis virescens* (tobacco budworms), *Spodoptera frugiperda* (fall armyworms), and *S. exigua* (beet armyworms)] eaten by Brazilian free-tailed bats (*Tadarida brasiliensis*) in an agricultural production region in Texas. Cloning and sequencing of insect DNA from field-collected fecal samples confirms the species identity of targeted moth species in the bats' diets. Using quantitative PCR (Q-PCR), the consumption of corn earworm moths, the most economically important moth pest in the region, is quantified as the number of copies of the corn earworm gene fragment per volume of fecal extracts. Consumption levels of corn earworm moths are compared and tied to population numbers and temporal infestation patterns of the pests in corn and cotton throughout the 2005 growing season.

Landscape Genetics as a Tool to Design Predictive Models for the More Efficient Management of Bats and Mines

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The relative infancy of the initiatives to manage bats associated with mines and caves, and the paucity of detailed baseline information has fostered a mode where empirical data have driven most management decisions. These empirical measures may often be based upon assumptions that overlook how variables such as the habitat morphology, interactions between metapopulations, or how the shear scale of the habitat may play a role in roost site fidelity over time. This may have led to costly efforts, where mitigation or reclamation sites were later found to be abandoned by the bats. Landscape genetics integrates information derived from the collection of genetic data from individuals and populations whose exact geographical location is known and the assessment of the abiotic and biotic ecological variables. Landscape genetic-driven databases are being used to manage a wide range of species. These databases have been successfully employed to generate temporal maps of habitat and species distributions, determine regions of habitat connectivity, locate zones of biodiversity, and model metapopulation viability. Spatial statistical analysis of genetic data linked to GIS databases will ultimately allow managers to predict the effect that specific environmental management strategies will have upon the genetic structure and movements of organisms, such as bats.

Karyotypic and Morphological Variation in the Bonneted Bat, *Eumops glaucinus*

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Eumops glaucinus, Wagner's bonneted bat, ranges from western and central Mexico through Central America and the northern two-thirds of South America. This species shows considerable morphological variation across its range, with individuals in the north being significantly larger in size. The northernmost populations, those in Florida, recently were elevated to species status as *Eumops floridanus*. Several different karyotypes are known for *E. glaucinus* throughout this extensive geographic range. Individuals from Mexico and Costa Rica have 2n=38, FN 64 whereas those from Colombia and Jamaica have 2n=40, FN=64. Another unique karyotype recently was discovered from western Ecuador that has 2n=38, FN=54. The objective of this study was to determine if DNA sequence divergence is correlated with the karyotypic differences within this highly variable species. In this study, individuals from Florida, Mexico, Cuba, Jamaica, Venezuela, Ecuador, Paraguay, and Peru were examined for genetic variation in the *cytochrome b* gene. Data were analyzed using Neighbor Joining in PAUP. Molecular sequence results demonstrate a similar pattern to karyotypic data: North American and Caribbean individuals cluster together, and specimens from Venezuela and Paraguay cluster together (both with low levels of sequence divergence). In addition, a substantially greater sequence divergence occurs between those specimens collected west of the Andes in Ecuador and all other specimens analyzed. *Cytochrome b* data from several other species of *Eumops* are included to illustrate sequence divergence patterns.

A Genetic Analysis of the Colony Structure of Fission-Fusion Tree-roosting Maternity Colonies of Big Brown Bats (*Eptesicus fuscus*)

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Bat biologists have dedicated time and energy to examining the structural characteristics of tree-roosts used by bats. Many of the structural characteristics of the roosts are known, but less is available on the genetic and social structure of these bats. Work with big brown bats (*Eptesicus fuscus*) in Cypress Hills Inter-Provincial Park, Saskatchewan, Canada, has provided an opportunity to exam the genetic structure of tree-roosting colonies in combination with long-term roosting studies. Within the 100 km^2 study area, three non-overlapping roosting areas (RA1, RA2, and RA3) were identified. Each roosting area contains a maternity colony of 20–40 adult females and their young. They roost solely in aspen trees (*Populus tremuloides*) and adhere to a fission-fusion form of roosting. The colony divides into several subgroups that roost in different trees within the roosting area during the day and at night subgroups break up and reform. The main objective of this study is to examine the genetic and social structure of these tree-roosting maternity colonies. More specifically, the first objective is to determine the mitochondrial and nuclear genetic structure of the three colonies. We expect more mitochondrial differentiation among colonies than within colonies because of a very low immigration and natal philopatry rate. The second objective is to correlate the relatedness of bat pairs within RA1 with their pair-wise sharing index (PSI). PSI quantifies roost sharing between individuals that were radio-tracked simultaneously. Field work was completed during the summers of 2002–2005. Bats were trapped at roost trees with a modified harp trap, and tissue samples from 116 bats were collected. This represents 41 juveniles and all the adult females (46) from RA1, 18 female adults and 7 juveniles from RA2, 3 female adults from RA3, and 2 adults of unknown roosting area. To date, four microsatellites (EF 6, EF 14, EF 15, and EF 20) have been optimized, and 77 bats have been genotyped. The microsatellites are variable with an allele range from 14–21 and high observed heterozygosity (80.5%–92.2%). Laboratory analyses are ongoing. Results for objective 2 will be presented for 36 bat pairs, and we predict that the relatedness between pairs will be positively correlated with PSI. Examining the genetic and social structure of tree-roosting colonies will enhance our understanding of the basic biology of these bats and lead to better informed roost management decisions for forest-roosting bats.

Bat House Use by a Colony of Florida Bonneted Bats (*Eumops floridanus*)

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The Florida bonneted bat (*Eumops floridanus*), formerly known as Wagner's mastiff bat (*Eumops glaucinus floridanus*), is an endangered species living in the southern portion of the Florida peninsula. This species has rarely been found over the past four decades, with no roosts reported since 1979. A colony consisting of at least one male and several females has taken residence in a bat house in a suburban backyard in North Fort Myers, FL (Lee County). The colony moved into a single chamber bat house, built by the Organization for Bat Conservation, in December 2002. This is the first record of *Eumops floridanus* using bat houses. Other bat house styles have been tested over the last three years and none have been successful at attracting the Florida bonneted bat. The colony has ranged between 8 and 14 individuals, including an albino. Offspring have been observed in the roost. The bat colony has maintained constant residence in the bat house through major Florida storms, including Hurricane Charlie in 2004.

Computer Simulation of Bat Movements: Importance in Understanding Roosting Assemblages and Conservation Strategies

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The question of the importance of caves for Greater Antillean bat assemblages, and possible impacts of conservation measures, was approached through the development of a flow model of the activity of bats. 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 and shape of the entrance, and of species composition within the roost. Based on the model, it is possible to assess the role of these factors in limiting the number of bats inside any particular cave. 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. Another improvement to the model is its capacity to handle situations where multiple species coexist within a roost. A higher proportion of species of bats in the Greater Antilles roost in caves, compared to the mainland Neotropics. The results offer an insight into mechanisms that may be at work in the structuring of Antillean bat communities. The second 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 strategies such as cave gating. A user-friendly interface was developed that allows the application of the algorithm to a variety of situations.

Bat Mortality and Wind Power: Is the Mountaineer Site in West Virginia Unique?

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Recent studies have documented high mortality rates for bats at certain wind power sites. For example in 2003, at the 44-turbine Mountaineer Center in WV, over 400 bats were found on

the ground below turbines during a period of about three months. Studies repeated last year at this site had a similar mortality number. Because of limited sampling and the removal of animals by scavengers, estimates of total mortality could be well over 1000 individuals. Questions remain as to why certain sites exhibit such high mortality levels, why specific forest-dwelling bat species (particularly tree-bats such as the red and hoary) are most affected, and if the fall migratory patterns of these bats play a role in their encountering turbines. In this study we characterize the Mountaineer site in terms of elevation, land use, wind etc., in order to determine if there are other sites in the area that have similar features. A probability map was created to identify areas of high congruence to the Mountaineer site. Less than 5% of the state had a close match to the site, indicating that the features of Mountaineer are uncommon. However, there is a good match between the Mountaineer site and the newly developed Mount Storm project that is located just to the east. This site has 200 turbines and is just one of many planned along the Allegheny front. It is hoped that studying these sites and learning more about which sites have high mortality rates will lead to a more informed criteria for siting turbines in the future.

Mating Display Behavior of the Big Brown Bat, *Eptesicus fuscus*

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The use of vocalizations to attract mates is common among vertebrates such as frogs and birds but is relatively uncommon in mammals. Bats are among the few mammals that use vocalizations during mating display behavior. The big brown bat, *Eptesicus fuscus*, is a polygamous and polyandrous species in which males defend small territories and emit stereotyped songs to attract potential mates. The goal of this study was to describe courtship vocalizations and display behavior of male big brown bats. Between October 2004 and January 2005, we observed and recorded mating from a captive colony of 80 big brown bats maintained at the University of Washington. Vocalizations were recorded using a Pettersson Elektronic, Inc. ultrasonic detector and BatSound 3.3 software. A video camera was used to capture mating behavior of the bats. Male bats were observed emitting a stereotyped courtship song when their heads were oriented toward the head of a particular female. The courtship song consisted of two phases that differed in both spectral and temporal features. The first phase consisted of 2–7 (8 ms) FM sweeps spanning a frequency spectrum from ~ 55–23 kHz and emitted at an average rate of 30 Hz. The second phase was composed of about twice as many calls and resembled a feeding buzz. The sweeps (2 ms) of the second phase were narrower in bandwidth (~ 40–23 kHz) and were emitted at an average rate of 70 Hz. Males were observed emitting the same song several times to a single female. Females did not always respond vocally, therefore, it was difficult to identify a vocal response to a male's song. Often, the female rejected a male by emitting a screech call and walking away or accepted a male by turning her body around and backing under the male. The songs of males were found to differ in the spectral-temporal structure. These differences could allow females to use song parameters to recognize individual males and therefore may facilitate mate choice in bats.

Bats (*Eptesicus fuscus* and *Myotis lucifugus*) as Potential Predators of *Photinus* Fireflies (Coleoptera: Lampyridae): Importance of Chemical Defenses and Luminescence

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Fireflies (Coleoptera: Lampyridae) are common nocturnal insects in New England and are potential prey of bats. However, North American fireflies contain chemical defenses (lucibufagins) making them toxic to many vertebrates. Most research on adult fireflies has focused on the role of luminescence in courtship displays. We hypothesized that flashes of adult fireflies (*Photinus*) also act as an aposematic signal to bats. Fecal analyses were conducted to confirm the absence of fireflies in the diet of *Eptesicus fuscus* and *Myotis lucifugus* in New England. Additionally, feeding experiments using adult *Photinus pyralis*, darkling beetles (*Tenebrio molitor*), and light emitting diodes (LED) were conducted to determine if bats reject prey due to chemical defenses or luminescent cues. As with previous studies, coleopterans made up the majority of bat diets but lampyrids were not observed in fecal contents. Bats trained to eat in captivity consistently rejected mealworms coated with *P. pyralis* but were not deterred by non-toxic luminescent mealworms. Preliminary results suggest that chemical defenses prevent bats from eating fireflies; however, bats may not discriminate between prey based on flash signals. We speculate that foraging bats identify inedible prey using auditory cues. Future experiments are planned to determine influence of wing-beat frequency and ‘experience’ on the ability of bats to identify inedible prey.

Winter Roosting Ecology of Eastern Red Bats (*Lasiurus borealis*) in Southwest Missouri

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Eastern red bats (*Lasiurus borealis*), one of the most commonly encountered bats in eastern North America, has had only modest attention given to the natural history and over-wintering strategies. We examined the red bat’s use of winter roosts in southwest Missouri. Radiotelemetry was used to track red bats for two winters (2003–2005) to diurnal roost sites. Seventy-three male and zero female red bats were captured during 130 net nights between November and March. Fourteen bats were tracked to 58 day roosts. Eleven red bats were located in 36 tree roosts that consisted of 44.4% eastern red cedar (*Juniperus virginiana*), and 55.6% hardwoods, including white oaks (*Quercus* spp.), red oaks (*Quercus* spp.), and a dogwood (*Cornus florida*). Ninety-seven percent of roost sites were located on the south side of the tree and 91% of the roost trees were found on southern facing slopes. Canopy cover was significantly different between northern and southern sides of tree roosts, with roost sites occurring significantly more frequently in the location with least canopy cover. Thirteen red bats were tracked to 22 leaf litter roosts. Ten red bats that were successfully tracked to tree roosts, switched from tree roosts to leaf litter roosts when ambient temperatures approached or fell below freezing. Leaf litter depth, percent leaf litter ground cover, density of woody stems, average diameter of trees, and aspect of roosts were found to be determining factors in the selection of winter leaf litter roosts. Management of over-wintering red bats may require a more serious look at the use of winter/spring forest burns and the availability of oak/evergreen forests.

Roosting Behavior, Social Structure, and Group Stability of the Big Fruit-eating Bat, *Artibeus lituratus* (Phyllostomidae, Stenodermatinae)

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The behavior of big fruit-eating bats, *Artibeus lituratus* (Phyllostomidae, Stenodermatinae), frequently involves the movement, or shuttling behavior, of males and females between available roosts. Sixty-four video recordings made at three roosts in the Andean region of Venezuela during one year, demonstrated that one male acquired more females than other males, suggesting that this male was associated with the highest quality roost. The high roost fidelity of males appears to be associated with the defense of highest quality roosts. The roosting behavior and mating system of *A. lituratus* is consistent with a resource defense polygyny hypothesis. We suggest that the shuttling movements of females may reflect their avoidance of ectoparasites.

Lek Mating System of the Buffy Flower Bat, *Erophylla sezekorni* in Exuma, Bahamas

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A lek mating system, defined as an aggregation of displaying males that females visit for the purpose of mating, can impose profound evolutionary pressures on species both by causing intense sexual selection and by influencing the social organization of species. Although lekking is found in a wide variety of bird species, it is extremely rare in other vertebrates, especially mammals. Currently, there are nine recognized species of lekking mammals that include only one species of bat, the hammer-headed bat, *Hypsignathus monstrosus*. We used capture techniques and a Sony DCR-TRV38 Nightshot video camera to study the social organization and mating behavior of the buffy flower bat, *Erophylla sezekorni*, in several caves on Exuma, Bahamas. The majority of research was conducted during the mating season, December 2004 to January 2005. A subset of adult males (approx. 15%) aggregate in solution domes in cave ceilings and use visual, auditory, and olfactory displays to attract females. The most conspicuous aspects of the male display are vigorous wing-flapping and wing-buzzing behaviors. Males also produce a supraorbital secretion with a strong garlic scent that may function as part of the display. Although this trait has been observed in both non-displaying and displaying males, it is more conspicuous in displaying males. Displaying males exhibit all aspects of the display behavior both during and outside of the mating season. Females congregate around lek arenas in the mating season to copulate with displaying males. Non-displaying males roost together in bachelor groups, spatially separated from lek arenas. Finally, mean condition indices (size-adjusted mass) for displaying males (0.82 ± 0.14) are significantly higher (Tukey post-hoc test; $p < 0.01$) than for non-displaying males (-0.19 ± 0.09) or females (-0.49 ± 0.08). This suggests that displaying males are better equipped to deal with the excessive energy demands of intense, long-term display behavior. Thus, current evidence indicates that *Erophylla sezekorni* is a rare example of a lek-mating mammal. We will discuss the implications of this rare mating system and the hypotheses that may best explain its evolution.

***Hidden Diversity in Hipposideridae**
Susan W. Murray, Boston University, Boston, MA
*** Susan Murray** received the **Karl F. Koopman Award**

Until quite recently taxonomists and field biologists relied almost solely on morphological characters to identify and define species. Some animals, however, live and communicate in a world dominated by tactile, auditory, and/or chemical cues, and therefore, species delimited strictly by morphology may be found to encompass two or more lineages that are genetically and/or behaviorally distinct. Morphologically "cryptic" species are predicted to be common in insectivorous bats, because they mostly function in an acoustic world and bat assemblages often contain species that are tightly packed in ecological and morphological space. Recent studies suggest that several species of hipposiderid bats contain more than one lineage that overlap in morphology but are acoustically and genetically distinct. The aims of this study were to examine phylogenetic relationships within Asian hipposiderids, and to identify any morphologically cryptic but genetically distinct lineages. We sequenced 540 bp of the mitochondrial *ND2* gene from 21 species of hipposiderids from eight countries in the Indomalay region, with sampling focused in peninsular Malaysia. *Hipposideros cineraceus* and *H. bicolor* were found to be polyphyletic in peninsular Malaysia and consisted of three and two divergent lineages, respectively. These data were supported by differences in echolocation call frequency between the lineages within both species. The results of this and several recent studies suggest that convergence in morphological characters may be common in Hipposideridae. Assessing hidden diversity and understanding patterns of morphology and genetics are essential to investigating limits of coexistence and assemblage structuring.

Distress Calls in Neotropical Bats
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"Distress calls" are typically viewed as sounds produced by an animal in situations of extreme stress, such as being captured by a predator or held by a researcher. With their notable acoustical abilities, bats provide a good opportunity to study the form and function of distress calls. By recording the sound produced and examining the situation the bat was in, the aim of this project was to define what a distress call is. Research was conducted at Lamanai Outpost Lodge in Belize, Central America, during May through July, 2005. Calls were recorded from bats tangled in mist nets, placed in a wire cage, and held by a researcher. Although very few bats called during the first two situations, on average almost half of all bats called when held by a researcher, but this varied greatly with species. Calls were analyzed with BatSound Pro (Pettersson Elektronik AB) and were compared within and between the different species. Although calls were usually broadband, able to be heard by humans, and often showed similar structure, each species had a slightly different call. Finally, using an ultrasonic speaker, distress calls were played at mist nets and swarming sites. Recordings of echolocation and static were played as controls. Capture rates and species caught were then evaluated to determine if distress calls served to attract or repel other bats from the area.

A Year in the Life of the Dusky House Flyer (*Eptesicus fuscus*)
Daniel J. Neubaum, Thomas J. O'Shea, and Kenneth R. Wilson, Colorado State University, Fort Collins, CO; U.S. Geological Survey, Fort Collins, CO

Despite prevalent use of anthropogenic structures as summer maternity roosts by bats, and the associated implications for public health, management, and bat conservation, very little quantitative information exists on characteristics of these roosts or why bats select them. In addition, winter distribution and roost requirements are poorly understood for most bat species in western North America. During the summers of 2001 to 2004 we characterized maternity roosts used by big brown bats (*Eptesicus fuscus*) in Fort Collins, Colorado. Radiotelemetry was used to document autumn migrations away from the maternity roosts during 2002 to 2004, and to locate rock crevices used as autumn roosts and presumed hibernacula in the Poudre River watershed, in northern Colorado. To determine roost selectivity by bats, variables for used and randomly selected buildings and rock crevices were compared at microhabitat and landscape scales. Used maternity roosts had exit points with larger areas, warmer average temperatures, and higher exit points. At the landscape scale distances to similarly categorized roosts were shorter, with used roosts occurring in areas with fewer buildings, more streets, and less traffic. Changes in the landscape, not only in the form of anthropogenic structures, but also in water availability and vegetation structure such as riparian forests, may have led to population increases and range expansions of this bat in the Fort Collins area. An altitudinal segregation of sexes was documented, with female biases at low elevations and male biases at high elevations in the summer, but even ratios at high elevations in autumn. Autumn roosts were higher to the ground above and below the exit point, with deeper crevices, and northwest facing aspects of hillsides. These roosts maintained cool, constant temperature regimes compared to randomly selected crevices. Some autumn roosts were used only for short periods. These transient roosts may offer passive re-warming energy savings for bats still active in early autumn. The large number of big brown bats found in summer roosts that cannot be accounted for by sizes of known hibernation colonies in caves, mines, and attics are likely using short elevational migrations to rock crevices that serve as winter hibernacula.

***Molecular Ecology of Big Brown Bats (*Eptesicus fuscus*): Hybrids or Not?**
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*** Melissa Neubaum** received the ***Bat Research News*** **Award**

Recent genetic studies documented the occurrence of several geographically distinct mitochondrial DNA (mtDNA) lineages of the big brown bat (*Eptesicus fuscus*) in North America. Individuals from two of these lineages, an eastern and a southwestern form, co-occurred within four maternity colonies in Fort Collins, Colorado. 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, body size, behavior, and susceptibility to different rabies virus variants. We captured big brown bats at maternity roosts throughout Fort Collins and several locations elsewhere in Colorado. Morphometric variables were measured and wing biopsies were collected for genetic analysis. Radiographs of pregnant female bats were taken in order to assess litter size (typically one in the western U.S.

and two in the eastern U.S.). Sequence analysis and restriction digests of the ND2 region of the mitochondrial DNA molecule were employed to determine mtDNA haplotype of individual bats. Haplotype was used to evaluate ecological data for litter size, body size, virus variant in bats killed by rabies, regional distributions, over-wintering habits, and composition of colonies and populations within Colorado. In addition, nuclear introns were used to determine if the two mtDNA lineages are hybridizing. Thus far, no outstanding distinctiveness has been found between the mtDNA haplotypes in litter size, pelage color, forearm size, coloniality, and virus variant in bats killed by rabies. Differences in distribution seem to occur along the Colorado Front Range, with an increasing proportion of southwestern haplotypes occurring farther south. Additionally, results from one nuclear intron have demonstrated hybridization between the two lineages.

Long-term Monitoring of Bat Populations Associated with Extensive Riparian Restoration in Las Vegas Wash, Clark County, Nevada

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This is a progress report of a long-term continuous monitoring program that was initiated in January 2004 to establish baseline inventory and habitat use of bats in Las Vegas Wash. This study provides baseline conditions in a currently highly disturbed riparian corridor, which is in the beginning stages of an extensive riparian restoration project. Continued monitoring through the restoration process will be able to document the effects of restoration process on the resident and transitory bat community. Three acoustic monitoring stations were established at approximately 1.6 km intervals in the wash. Each station houses an Anabat II detector and a Compact Flash Storage Zero-crossings Analysis Module (Titley Electronics, Ballina, NSW, Australia) powered by a 5-watt solar panel and collected data all night every night. Locations were selected to reflect the variations in habitat composition and structure found within the wash. Through 2004, 17 species of bats were recorded; three species were previously known from a single historic record and six species were not know to occur within Las Vegas Valley, including a species new to the State. Patterns of occurrence and intensity of use are forming. Marked differences of use by various species have been found among the three monitoring sites. Continued monitoring will allow determination of annual variations in occurrence and use due to changing weather patterns as well as the effects of riparian restoration.

An Opportunity to Implement a North America-wide Sampling Frame for Collecting Bat Data

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Improving our understanding of geographic distributions and adequately addressing population-level questions for North American bat species require data collection and assessment across large geographic areas. Incorporating a standardized sampling frame and probabilistic sampling methods for selecting survey sites for such broad-scale efforts can increase efficiency of sampling, improve data inference, and allow estimations for population parameters of interest. Additionally, implementing a standardized sampling frame for bats at a large geographic scale can allow for cumulative assessments of data collected across studies or surveys. A sampling frame and method for randomly selecting sample units specifically designed for bat surveys has been constructed for continental North America. The sampling frame, known as the “bat grid,” has been implemented across the northwestern United States as a basis for conducting inventories on species presence. The achieved benefits from using this standardized grid include realizing common objectives and improving consistency and predictability of data collection. These as well as other benefits could be achieved across North America by making the bat grid available for incorporation with other survey or research efforts occurring across the continent.

Whisper in My Pinna: Social Learning, Persistence, and Memory in the Frog-eating Bat, *Trachops cirrhosus*

Rachel A. Page and Michael J. Ryan, University of Texas at Austin, TX

The fringe-lipped bat, *Trachops cirrhosus*, feeds on frogs that it locates using the advertisement calls male frogs produce to attract their mates. Given acoustic cues alone, *T. cirrhosus* is able to determine the palatability of a prey species. In an earlier study, we investigated the flexibility of the associations *T. cirrhosus* forms between acoustic stimuli and prey quality, and found *T. cirrhosus* to be highly flexible in its ability to reverse prey-cue/prey-quality associations. In this study, we investigated the degree to which learned associations endure over time in the absence of subsequent reinforcement. In addition, we investigated the role of social interactions in the acquisition of novel foraging responses. We quantified the rate of acquisition of novel foraging behavior in three groups of bats: (1) a trial and error group, (2) a social facilitation group, and (3) an observational learning group. We found that the mere presence of an untrained conspecific was not sufficient for the rapid acquisition of a novel foraging association, whereas bats that were allowed to observe a trained conspecific learned quickly. We also examined the sensory cues instrumental in social learning behavior. Together these studies investigate the role of learning and memory in the foraging behavior of the frog-eating bat, *Trachops cirrhosus*.

Morphology and Systematics of *Rhinolophus* from Lore Lindu National Park, Sulawesi, Indonesia

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The genus *Rhinolophus*—the sole genus in the family Rhinolophidae—is a speciose genus distributed throughout the Old World. Numerous species in the genus appear—as currently recognized—to be distributed across physical and geographic barriers that theoretically should serve as boundaries to gene flow. In fact some of the species’ ranges clearly lack biologically meaningful relevance and clearly represent complexes of multiple species constituted by morphologically cryptic taxa—an ever present problem in this morphologically conservative genus. As such, there is a strong need to critically reexamine morphological species limits, as well as to improve our taxonomic resolution with molecular data. One particular case in point is *Rhinolophus* species on the island of Sulawesi in Indonesia. Sulawesi is an oceanic island and has never been in contact with other landmasses. Although currently a single island, it is in fact constituted by land fragments from Australia, Philippines, Sunda Shelf, and autochthonous fragments, all of which have coalesced into a single land mass within the past one million years. At least 60% of its mammal fauna are endemic species. It is improbable that small, weak flyers—such as most rhinolophids—could regularly disperse to and from Sulawesi and thereby maintain gene flow between Sulawesi and other distinct and distant island populations. We therefore hypothesize that *Rhinolophus* species found on Sulawesi, although nominally conspecific with those found elsewhere throughout the region, are in fact distinct from those found on other Southeast Asian islands or the mainland. To test this working hypothesis, we compared putative *R. arcuatus* from Lore Lindu National Park in central Sulawesi, to bats from other islands in Southeast Asia, as well as *R. arcuatus* from the type locality (the Philippines). Principal component analysis was used to compare sixty morphological measurements taken from the specimens in question. To further support our hypothesis, we sequenced the mitochondrial *cytochrome b* gene and the control region for the same individuals, and compared the sequences among each other and previously published sequences. Our results indicate that the species *R. arcuatus* may contain at least one cryptic species and thus should be revised. Given the geographically restricted nature of the current research, we strongly support the need for further study in this biogeographically complex taxon and region.

Proposal: Mating Behavior of the Little Brown Bat, *Myotis lucifugus*

Krista J. Patriquin, Dalhousie University, Halifax, Nova Scotia, Canada

Sexual selection theory suggests that females should exercise mate choice and males should compete for access to females and to attract females. However, based on limited observation, it has generally been assumed that many bats, including little brown bats, *Myotis lucifugus*, mate promiscuously and randomly. Yet, with the exception of one study, the mating behavior of little brown bats has not been investigated systematically. Limited observations of little brown behavior in hibernacula suggest there are opportunities for females to exercise pre-copulatory mate choice. Furthermore, females store sperm from multiple males over the winter, which also allows for sperm competition and cryptic female choice. However, establishing whether mate choice translates into differential reproductive success among males is difficult because adult males and females roost separately in the summer. Therefore, the goals of my research are to systematically document the mating behavior of little brown bats, establish whether female mate choice, male-male competition and sperm competition occur, determine whether there is a skew in reproductive success among males, and to establish the mechanisms by which any skew might be established. I will address my objectives through a combination of behavioral observations in natural and captive conditions where I will quantify individual characteristics of captured bats, mark individuals, and document their behavioral interactions. I will also obtain DNA from captured adults and subsequent offspring to determine paternity of juveniles. Because few people have attempted a study of this nature with bats, establishing an appropriate study design is proving quite challenging. Therefore, I am presenting this poster in an effort to gain useful feedback.

Interspecific Variation in Moth Predation of a Tropical Bat Fauna
Chris R. Pavey, Chris J. Burwell, and Damian J. Milne, Parks and Wildlife Service, Northern Territory, Australia; Queensland Museum, Brisbane, Australia

The co-evolution of eared insects and echolocating bats is a topic of considerable interest in evolutionary biology. The allotonic frequency hypothesis proposes that the proportion of eared moths in the diet should be highest in bats whose echolocation calls are dominated by frequencies outside the optimum hearing range of moths, i.e., < 20 kHz and > 60 kHz. The hypothesis was tested on an ecologically diverse bat assemblage in northern Australia that consisted of 23 species (5 families, 14 genera). Prior to the study the hypothesis had never been tested in the species-rich tropics. Peak frequency of signals of bats within the echolocation assemblage ranged from 19.8 kHz (*Chaerephon jobensis*) to 157 kHz (*Rhinonicteris aurantius*); however, the echolocation assemblage experienced by eared moths was greatest in the frequency range between 20 and 50 kHz. A strong positive relationship existed between peak call frequency and percentage of moths in the diet for a sample of 16 bats from the assemblage representing all 5 families and 13 genera ($p < 0.01$). The relationship remained strong when the three species with low intensity calls were excluded from the analysis. When the two species with high duty cycle constant frequency signals were removed, the relationship was weaker but still significant ($p < 0.05$). In contrast to previous research, eared moths comprised only 54% of moth captures in light traps set at bat foraging grounds; however, eared moths were significantly larger than non-eared individuals (8.66 mm vs. 6.64 mm forewing length). These results suggest that the pattern of incorporation of moths into the diet of tropical bats is similar to that already established for bat faunas in sub-tropical and temperate regions. We consider that the evidence so far accumulated in support of the allotonic frequency hypothesis is a strong indication of the widespread geographical occurrence of moth-bat co-evolution. However, a number of shortcomings in the available evidence will be discussed.

The Effect of Water Quality on a Nocturnal Food Web in the Cape Fear River Basin
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The headwaters of the Cape Fear River Basin are in the Buffalo Creek watershed in North Carolina. The creek receives nitrogen-enriched effluent from a waste water treatment plant (WWTP) and is impaired due to instream habitat degradation, nutrient enrichment, and high levels of fecal coliform bacteria. The nitrogen enrichment in lower trophic levels of this food web and the presence of bat species in the stream provide an ideal system to study the effects of water quality on bats and their prey. In June–August 2005, we sampled along the creek using a paired design up- and downstream of the WWTP. We collected data on insect abundance, bat species abundance, bat commuting and foraging activity, and bat diet. To sample insects we used emergence, malaise, and sticky-traps. We identified all captured insects to order and family. To survey bat activity and which species were present, we recorded echolocation call sequences in real time and time expanded modes using Pettersson D240x bat detectors. Call sequences were analyzed using SonoBat. Sequences were identified to species and separated into commuting or foraging activity. To sample diet, we captured bats along the creek to collect fecal pellets. In the lab we examined pellets and matched insect parts with known insects. We also analyzed data collected in 2004 (we sampled for a total of 32 nights in 2004, of which16 were paired up- and downstream of the WWTP). Results from 2004 were as follows. We found no differences in the total number of insects up- and downstream of the WWTP. However we did find a difference in the types of insects. Abundant insects upstream were Dipterans, Lepidopterans, and Coleopterans, whereas there was a trend toward more Homopterans downstream of the WWTP. Bat species that commonly use the creek include *Pipistrellus subflavus*, *Nycticeius humeralis*, *Lasiurus borealis*, *Lasionycteris noctivagans*, and *Eptesicus fuscus*. We found that there were more *E. fuscus* / *L. noctivagans* sequences upstream whereas there were more *P. subflavus* sequences downstream of the WWTP. There was no difference in the mean number of sequences/night recorded up- and downstream of the WWTP. However, bats downstream of the WWTP spent 25% of their time foraging while bats upstream spent only 12% of their time foraging. Fecal analysis revealed that bat diet reflected the available insects. We have demonstrated an effect of water quality on both the prey types and predator types and behaviors in this food web.

Spatial Memory and Navigation in Big Brown Bats (*Eptesicus fuscus*)

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Insectivorous bats fly in regular, consistent paths through cluttered areas, exhibiting spatial memory both in the field and under lab conditions. To test their system of spatial orientation and landmark recognition, a matrix of vertically hanging chains in a 4.5 m wide, 10.5 m long, and 2.6 m high flight room has been constructed to simulate a cluttered flight space. The chain matrix is 14 chains wide (spaced 25.4 cm apart) and 13 chains deep (spaced 39.3 cm apart), creating a total area of nearly 15.5 m^2. Several recently captured *Eptesicus fuscus* are trained to fly through this chain matrix, following preset routes created by clearing gaps in the chain network. Their flights are recorded in the dark with a stereoscopic pair of Indigo Merlin thermal-imaging cameras. The camera images are transcribed to tape (along with a soundtrack of the bats' sounds) on Sony Video Walkmans. After the bats have become accustomed to a particular route, the chains are removed, and the bat's flight is analyzed to determine whether it remembers and follows its previous, trained course. Preliminary observations seem to indicate that the bats will follow their trained courses for a short while, before updating their flight behavior to take advantage of newly open territory. Further experiments will utilize multiple cleared routes to test bats' ability to analyze complex cluttered environments and make choices based on remembered orientation to landmarks.

***Differences in Flight and Echolocation Behavior of *Myotis nattereri* when Foraging near Coniferous or Deciduous Trees**

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*** Wiebke Pflaesterer** received the **Basically Bats Wildlife Conservation Society Award**

Natterer's bats (*Myotis nattereri*) are typical edge space aerial foragers that search for prey near vegetation by echolocation. Close to vegetation the bats have to separate prey echoes from the echoes generated by the background. The difficulty of this task depends on the type of vegetation. For example, leaves of deciduous trees generate stronger echoes than the needles of conifers. Therefore, we assume that with decreasing distance between prey and vegetation, bats should have more problems finding prey near deciduous than near coniferous trees. To test this hypothesis we trained Natterer's bats in a flight room to catch prey that was offered at different distances in front of artificial hedges simulating coniferous or deciduous trees (*Pinus* and *Ficus*). Under illumination with an IR stroboscope we recorded the flight and echolocation behavior of the bats while they were capturing tethered mealworms, and synchronized the reconstructed flight paths with their echolocation calls. The aim of the study was to investigate strategies in echolocation and flight behavior that the bats might use to cope with detection tasks of increasing difficulty. The degree of difficulty was indicated by the number of unsuccessful search flights in which the bat approached the hedge but did not attack the mealworm, and by the number of turns in front of the hedge before the bats caught the mealworm in successful flights. At both vegetation types the distance between prey and vegetation influenced the flight behavior. With decreasing distance between prey and hedge the number of unsuccessful search flights increased. Furthermore the animals made more turns before a capture. Additionally, hunting in front of the deciduous tree was more difficult than catching prey close to the coniferous hedge, especially when the distance between prey and the closest twigs was less than 10 cm. Only two of four trained bats were able to detect and capture mealworms that were offered at a distance of 2 cm to the broad-leaved ficus tree, whereas all of them were successful in front of the artificial pine tree. At distances of 20 or 40 cm the vegetation type did not affect the capture performance of the bats. The influence of the vegetation type on the echolocation behavior will also be described.

***Lipid Composition and Hibernation in Little Brown Bats, *Myotis lucifugus* in Québec, Canada**

Marie-Helene Pitre and Don Thomas, Sherbrooke University, Québec, Canada

*** Marie-Helene Pitre** received the **Bat Conservation International Award**

Until recently, hibernation studies focused mainly on rodent mammals. These studies allowed us to understand the importance of polyunsaturated fatty acid (PUFA) in the expression of torpor. Because hibernating mammals cannot synthesize PUFAs, they must be obtained through their food. But what about insectivores? How can they undergo sustainable hibernation when the literature has clearly recorded very low PUFA concentrations in insects? This question is the goal of a study on the little brown bat (*Myotis lucifugus*) that began in fall 2004 in Québec (Canada). Using gas chromatography, this study determines the concentration of PUFA in fat reserves of *M. lucifugus* and also in its insect diet.

The Adaptive Function of Tiger Moth Clicks against Echolocating Bats: An Experimental and Synthetic Approach

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We studied the efficiency and effects of the multiple sensory cues of tiger moths on echolocating bats using the northern long-eared bat, *Myotis septentrionalis*, a purported moth specialist that takes both surface-bound prey (gleaning) and airborne prey (aerial hawking), and the dogbane tiger moth, *Cycnia tenera*, an eared species unpalatable to bats that possesses conspicuous coloration and sound-producing organs (tymbals). This is the first study to investigate the interaction of tiger moths and wild-caught bats under conditions mimicking conditions found in nature demanding the use of both aerial hawking and gleaning strategies by bats, and the first to report the sounds of tiger moths while under aerial attack. During both aerial hawking and gleaning trials, all muted *C. tenera* and perched intact *C. tenera* were attacked by *M. septentrionalis*, indicating *M. septentrionalis* did not discriminate *C. tenera* from palatable moths based on potential echoic and/or non-auditory cues. Intact *C. tenera* were attacked significantly less often than muted *C. tenera* during aerial hawking attacks: tymbal clicks were therefore an effective deterrent in an aerial hawking context. During gleaning attacks, intact and muted *C. tenera* were always attacked and suffered similar mortality rates suggesting that while handling prey this bat uses primarily chemical signals. Our results also show that *C. tenera* temporally matches the onset of click production to the 'approach phase' echolocation calls produced by aerial hawking attacking bats and that clicks themselves have negative consequences for attacking bats. These findings support the hypotheses that the clicks of arctiid moths are both an active defense (through echolocation disruption) and a reliable indicator of chemical defense against aerial-hawking bats. We suggest these signals are specialized for an aerial context.

Variation in Populational Size and Composition of a Summer Colony of Endangered Gray Bats (*Myotis grisescens*)

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 *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 us to investigate these fluctuations, and to examine if there is significant variation in sex and age composition of the population in Blowing Springs Cave throughout summer. Fieldwork was conducted to capture, examine, and immediately release gray bats between March and November of 2004 and 2005. Two nights were spent at the site each visit. An emergence count was done in the first night, and capturing, examining, and releasing of bats the following night. The colony was a maternity colony. In both 2004 and 2005, significant fluctuations in population size and changes in sex-age ratios were observed. Numbers of bats increased after hibernation, decreased during the maternity period, and doubled in size with volant young. Numbers dropped toward the end of summer, then increased again in early fall, which indicates that the cave might serve as a transitional cave for migrating bats. Most bats had left the cave in mid-October. When proportions of bats captured were correlated with time, a negative, linear relationship was found in adult females, and positive, linear relationships were found in male and female juvenile gray bats. No linear relationship was found in adult males. Knowing more about this colony will help in future management decisions.

Spinturnix americanus: A Spinturnicid Mite Found on the Endangered Gray Bat (_Myotis grisescens_), Identified with SEM

Petra Redinger, Troy L. Best, Christine A. Sundermann, and Roland R. Dute, Auburn University, AL

Several species of mites have been recorded from the endangered gray bat (*Myotis grisescens*). Mites found on *Myotis grisescens* include *Spinturnix banksi* (patagia), *S. americanus* (patagia), *S. rectalis* (female – rectum, male – patagia), *Macronyssus jonesi* (patagia and fur), *Paraspinturnix globolus* (anal cavity and patagia), *Neomyobia caudata*, *Pteracarus chalinolobus*, *Trombicula tibbettsi*, *Duschogastrial pipistrelli*, *Teinooptes lasionycteris*, with the three latter species found in fur and on patagia. *Spinturnix americanus* and *S. banksi* are the only two species found only on the patagia. The purpose of this study was to collect mites from *Myotis grisescens*, and to determine what species were found. On 1 October 2004, 97 *M. grisescens* were captured with a harp trap as they emerged from their roosts for feeding at Blowing Springs Cave, Lauderdale Co., Alabama. Mites were randomly removed from patagia with small, blunt forceps to prevent membranes from being damaged, and preserved in formaldehyde. Specimens were dried and mounted for scanning electron microscope imaging, and 15 SEM images were taken. Pictures were also taken with a Nikon digital camera mounted to a compound microscope for additional identification. All mites collected were *S. americanus*. Mites are not beneficial to their hosts, but not much is known about parasite-host relationships and possible energy costs or diseases involved. It would be interesting to know more about these relationships, especially for threatened or endangered hosts.

Ecological and Behavioral Energetics of Brazilian Free-tailed Bats (_Tadarida brasiliensis_) Using Infrared Thermography

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An organism's body temperature (T_b) has profound influences on its physiology, behavior, and ecology. Although many mammals maintain a steady optimal T_b for development and reproduction, it is evident that T_b may vary markedly on short-term and long-term scales depending on activity levels, physiological demands, and microclimate conditions. From an investigative perspective, body temperature varies further depending on how or where temperature is recorded. An additional concern is the fast rate of heat conduction and changes in heat production resulting from contact with researchers, conditions of captivity, and the additional stress of attached or implanted instrumentation. Infrared thermography facilitates analysis of T_b with minimal contact and disturbance of organisms in their natural habitats. We applied infrared thermal (IR) imagery to studying physiology and behavior of Brazilian free-tailed bats (*Tadarida brasiliensis*) with Indigo Systems Merlin and FLIR Systems Thermacam S-65 IR thermal cameras. The maternity colonies studied were located at Frio Cave in Uvalde, Texas, Ney Cave in Bandera, Texas, and Seco Creek Bridge in D'Hanis, Texas. Variation in T_b (surface) of adult males and pregnant, lactating, and non-reproductive females before and after nightly flights was compared to their T_b (rectal) to examine heat conductance from the body core to different external regions of the bat. Heat dissipation from these surfaces was explored by measuring the change in T_b (surface) occurring over time upon emergence from isothermal roost conditions. We also analyzed thermal images of free-ranging bats upon emergence from the roost and upon return from foraging bouts. Thermal analyses of cluster patterns and behavior of roosting bats were also considered. Although T_b is variable throughout the daily activities of *T. brasiliensis*, the success and behavior of these bats in part reflect their ability to exploit these variations to their reproductive and ecological advantage.

Distinguishing Megachiropteran Species Using Morphological Characteristics in Kasanka National Park, Zambia

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Throughout Africa available information about regional bat fauna is by no means comprehensive. Large regions of the continent have not been sampled, and very few areas have been extensively studied. The Megachiroptera in particular have been neglected as a group, with few attempts at direct comparison and discrimination of multiple species. Sympatric species of epauleted and dwarf epauleted fruit bats can be nearly indistinguishable, and this may contribute to the absence of comparisons in the literature. Species designations have been contested and changed multiple times over the last 100 years, with species often being misclassified and reclassified, or some species demoted to subspecies status. This study addressed the lack of information about species discrimination and fruit bat assemblages in Zambia. The last comprehensive mammal list for Zambia was published by Ansell in 1978, and provides only sparse records of species occurrences for most chiropteran species in the country. No systematic or extensive sampling at the study site has ever been conducted. We conducted mist netting in Kasanka National Park, Zambia, from November to December 2003 to collect and identify fruit bat species. Data collected on 125 *Epomophorus* and *Micropteropus* were examined to test whether morphological measurements and the postdental palate are sufficient for identifying the species in the region. We used a combination of published data, field data, and multivariate statistics to address this goal. Statistical methods for comparing species are needed because the number of megachiropteran species, and their resemblance to one another, makes it extremely difficult to conclusively identify some species in the field, and geographical variations in species types only increases this uncertainty. In many regions the main characteristic separating sympatric species that otherwise share size and color characteristics is the configuration of their postdental palatal ridges. This study is the first to statistically analyze morphological data from these species as an alternative approach for distinguishing them. Our results demonstrate a need for further research into species' characteristics in the region.

Interspecific Variation in the Ecology of Tent-roosting Bats in Eastern Ecuador

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Twenty-three species of bats are known to roost in tents constructed from modified plant parts. Although previous studies have documented substantial variation in the architecture of tents, it is not known to what extent this variation represents behavioral differences among bat species. For example, regional differences in the availability of plant species may influence tent architecture, precluding comparisons between bat species observed at different sites. This study examined architectural variation among six sympatric species of tent-roosting bats in eastern

Ecuador. Roosts were assessed with respect to architecture, plant species, spatial positioning, habitat association and seasonality of construction. To detect interspecific differences, tents of individual bat species were compared by multivariate discriminant analysis. Two species, *Artibeus anderseni* and *Vampyressa bidens* each roosted in tents that were architecturally different from those of other species, and roosts of *Mesophylla macconnelli* and *A. gnomus* overlapped only to a minor degree. Conversely, roosts of *Rhinophylla pumilio* and *V. thyone* were nearly indistinguishable from one another although they differed significantly in mean values for several parameters. These results indicate that some architectural variation in tents reflects behavioral differences in the species responsible for their construction. However, significant overlap in tent architecture exists among species, which may be partially attributed to sequential use of roosts by multiple bat species.

Temperature Selection by the Bat *Molossus molossus*

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The bat *Molossus molossus* is widespread in the New World, ranging from Mexico to Uruguay and northern Argentina. It is the only member of the genus to invade the West Indies and currently lives on most islands of both the Greater and Lesser Antilles. This molossid is found throughout Puerto Rico, although it is most common in areas of human habitation, where it often roosts in human dwellings. We measured temperature preferences in the laboratory using a "Thermopreferendum chamber." In addition, an environmental chamber was provided with an artificial roost and an infrared camera to observe behaviors at various temperatures. In the laboratory, bats show increased activity at temperatures over 35° C, and actively try to avoid temperatures over 38° C. Most bats selected temperatures between 30° C and 32° C, although many selected temperatures as low as 18° C. However, few bats selected temperatures above 32° C. Temperature was also measured in four "natural" roosts: three unfinished concrete walls, and a wooden house. Temperature inside the "natural" roosting areas may vary from 20° C to 45° C, although bats appear to avoid the higher temperatures. Overall, *M. molossus* selects a wider range of temperatures than cave-dwelling bats. The results may have applications towards the improvement of "bat houses" for this species.

Terrestrial Locomotion of New Zealand's Short-tailed Bat (*Mystacina tuberculata*), with Comparisons to the Common Vampire Bat (*Desmodus rotundus*)

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P. D. Dwyer once called *Mystacina tuberculata* "the most sure-footed of all bats," and J. S. Altenbach later commented that "no other species possess the extreme terrestrial agility" of *Desmodus rotundus*. Both are far more terrestrially adept than most other bats, and their phylogenetic relationship suggests that their terrestrial skills are independently evolved, but until now they have not been compared thoroughly. To better compare the locomotion of these taxa, we used a high-speed camera (250 Hz) and a treadmill to measure stride frequency and footfall patterns of both species over a range of speeds. Unlike *D. rotundus*, which walk at low speeds and perform a bounding run at high speeds, *M. tuberculata* used a lateral sequence walking gait across all speeds surveyed. Their maximum speed on a treadmill (0.69 m/s) fell between the greatest walking (0.56 m/s) and running (1.14 m/s) speeds of *D. rotundus*. The walking gait footfall patterns of the two species are remarkably similar, but body posture while walking is quite different. Compared with *D. rotundus*, the body of *M. tuberculata* is held much closer to the ground, and the wings are held in a more sprawling position. At higher speeds, this broad forelimb stance permits *M. tuberculata* to swing the hindlimbs below (ventral to) the plane of forelimb movement. As a result, fast-moving *M. tuberculata* (unlike *D. rotundus*) can increase stride length to such a degree that they place the hind foot on the ground ahead of (cranial to) the wrist (carpus) on the same (ipsilateral) side of the body.

Development of an Automated Bat Counter for Large Emergences Using Digital Thermal Infrared Videography

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Counting the number of bats emerging from caves supporting large colonies of bats can be a very challenging task. We have previously described a promising technique using digital image processing of thermal infrared (IR) videography to automate this task. In an effort to further develop and test this capability, ten gray bat (*Myotis grisescens*) maternity caves within Alabama, Arkansas, Kentucky, Missouri, and Tennessee were sampled during June and July 2005 using the thermal infrared videography technique. Simultaneous with these surveys, local resource agency personnel, responsible for monitoring bat populations at these caves, performed census surveys using a variety of established techniques, including visual emergence counts, guano deposition surveys, and direct observation of clustering density and area coverage within the roost site. This paper describes procedures used and results from these various surveys. There was general agreement between the experimental thermal IR technique and the other established techniques, although the numbers seldom exactly matched. Potential sources of error in these techniques are discussed. The next steps planned towards finalizing and validating the digital image processing technique, including potential use of low-cost cameras, are described.

Special Observations on the Social Behavior of the White Honduran Bat, *Ectophylla alba*

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Ectophylla alba modifies leaves into tents creating a space to live. It has been proposed that *E. alba* lives in mixed groups most of the year, but changes to harems after the birth of offspring. Accordingly, the presence of a post-partum estrus was suspected. It was also speculated that there was little chance of finding reciprocal care of offspring by females in the shelter. Recordings of 35 individuals in 7 different tents in La Tirimbina Biological Reserve, Costa Rica, reveal the presence of what we describe as a post-partum estrus, while offspring were volant and between 15 and 25 day old. Some males attempted to copulate, pushing their chest against the female's back and biting it. Based on this observation, we propose that harems are not formed immediately after birth, but rather are formed when offspring are more independent. The incidence of two males trying to copulate in the same tent at the same time suggests an additional hypothesis that harems do not provide exclusive copulatory rights to dominant males. We recorded a second male copulating with females in another dominant male's harem on two occasions. Additional observations included two males trying to copulate with an infant and an apparent lack of reciprocal care of offspring by females. These observations contribute to our understanding of the poorly known, yet apparently complex roosting ecology of *E. alba*.

Ecological and Evolutionary Implications of the Feeding Behavior of the Silky Short-tailed Bat, *Carollia brevicauda*: An Experimental Study

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Phyllostomids exhibit the greatest dietary diversity within any family of living mammals. Although primitive phyllostomids were insectivores, more than half of the living species are frugivores largely within the subfamilies Carolliinae and Stenodermatinae. Anatomically, carolliines are less specialized for frugivory than the highly derived stenodermatines. Although carolliines feed mostly on fruits, their primitive anatomy suggests that the first adaptations of the phyllostomids towards frugivory were behavioral. Therefore, we hypothesize that the Carolliinae potentially illustrate a primitive stage in the evolution of frugivory that culminated with the specialized Stenodermatinae. With this in mind, we studied the feeding behavior of a typical carolliine, *Carollia brevicauda*, from which we had previous dietary information. We videotaped the exploratory, capture, handling, and chewing behavior of this species while feeding on four species of fruit (*Piper aduncum*, *Psidium caudatum*, *Solanum* sp., and *Vismia baccifera*) in its natural environment and in captivity. We described the biting behavior by referring to the order of appearance of four bite types, i.e., bilateral precanine, unilateral precanine, bilateral molar, and unilateral molar. We found that *Carollia brevicauda* is similar to the other species of the genus in the behavior that precedes fruit capture, using smell for search purposes and then echolocation to determine the exact position of the fruits. As fruit hardness increased, we found that the time, number of bites, and thumb use also increased. In contrast, *C. brevicauda* exhibited little variation in the bite types used to eat the four species of fruits. It used postcanine bites, especially bilateral molar bites, almost exclusively. The response to increasingly hard fruits was limited to an increase in the numbers of the strongest bite type (i.e., the unilateral molar). This lack of variation in the bite types might be associated with the lack of specialization in *C. brevicauda*'s skull, with features that include a long, narrow rostrum that is relatively inefficient at transferring bite forces to the anterior dentition, and molar occlusal surfaces that are insufficient for the prolonged grinding that hard fruits require. Despite these restrictions, *C. brevicauda* can consume soft fruits and arthropods more rapidly and thus, in that sense, more efficiently than stenodermatines.

Arousal Time and Variables that cause Red Bats (Lasiurus borealis) to Arouse from Torpor during Prescribed Burns

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There have been very few studies on bat behavior during a prescribed burn, but there are anecdotal reports that red bats have been observed flying from a fire and found burned after a fire. During the cold season, bats go torpid to conserve energy. Red bats will burrow into leaf litter and go torpid when it is cold. Torpor is a chemically induced stupor that prevents a bat from moving quickly. Once the bat arouses from torpor, it is able to fly. The objectives of this study are to determine factors that trigger red bats to arouse from torpor during a burn. Another part of my project is to study how long it takes red bats to arouse at different temperatures. Some variables that may cause arousal are smoke, noise, and/or a combination of these variables. I predict that the combination of smoke and the sound of fire will best cause arousal. Observations in the field and lab experiments have been conducted to measure the effects of different variables. I have attained some preliminary data suggesting that at different temperatures, bats arouse at different times. Some tests show that it may take up to an hour for a red bat to arouse from torpor. This study will help conservation managers determine the optimal burning conditions so red bats are not wiped out.

Landscape-level Habitat Modeling of Bat Communities in the New River Gorge, Gauley River, and Bluestone River National Park Areas in the Central Appalachians

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Bat community surveys using acoustical methods are useful for creating 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 acoustical equipment during the summers of 2003 and 2004. At each sample point we recorded habitat type, stand class, mid-story condition, height of the canopy, width of canopy gaps, and used GIS to determine aspect, slope, elevation, along with distance to selected landscape features, to develop species-specific habitat models. We detected ten bat species, including several species of conservation concern, such as the hoary bat (*Lasiurus cinereus*), silver-haired bat (*Lasionycteris noctivagans*), small-footed myotis (*Myotis leibii*), and the endangered Indiana bat (*Myotis sodalis*). Resulting habitat models based on bat presence or absence will be discussed. The habitat models generated in this study will aid bat conservation efforts by providing land managers with information regarding bat habitat relationships.

A Mechanism for Sex Recognition in the Big Brown Bat: The Potential Use of Pheromones

Cynthia N. Schmaeman and Mary T. Mendonça, Auburn University, AL

A variety of studies in bats have demonstrated the use of pheromones for mother-young recognition, roost mate recognition, and male-male recognition in harem systems. Surprisingly, this sensory mode has not been implicated in male-female recognition or courtship and mating behavior. During the mating (November–March) and the non-mating season (April–October), we tested sex-recognition of male and female big brown bats using actual bats or swabs of bats. We placed individual male and female bats in a Y-maze and exposed them to either (1) same sex vs. blank, (2) opposite sex vs. blank, or (3) same sex vs. opposite sex. Male bats preferentially chose ($n = 69$) and spent significantly ($p = 0.0053$) longer periods of time in the female arm of the maze when presented with male vs. female choice. Additionally, males tended to choose ($n = 16$) and spend more time ($p = 0.0017$) in the male arm when presented with a male vs. blank choice. These results suggest sex recognition based on pheromonal cues.

Anatomical Specializations of the New Zealand Short-tailed bat (*Mystacina tuberculata*) for Quadrupedalism, and a Unique Method for Increasing the Rate of Bat Captures

William A. Schutt, Jr., Daniel K. Riskin, John W. Hermanson, and Stuart Parsons, C.W. Post College of Long Island University, Brookville, NY and American Museum of Natural History, New York, NY; Cornell University, Ithaca, NY; University of Auckland, Auckland, New Zealand

Quadrupedal locomotion varies tremendously in bats—from clumsy scrambling to remarkable feats of agility and speed. Until recently, only the common vampire bat, *Desmodus rotundus*, has been well studied in this regard. Skeletal and fluid-preserved specimens of *Mystacina tuberculata* were examined at Te Papa Tongarewa (Museum of New Zealand) in Wellington, New Zealand. A number of interesting morphological adaptations were noted, including an apparently unique calcar, which can be rolled up in the uropatagium and fixed against the calf. In addition to retracting the calcar during quadrupedal locomotion, we propose that this anatomical arrangement may strengthen the hind limb during walking and thus serve a role in structural support. A similar arrangement was reported in naked bulldog bats, *Cheiromeles* (Molossidae), but in this genus, the calcar is bound permanently to m. gastrocnemius. Finally, with some lingering debate over the species status of the presumably extinct greater short-tailed bat, *M. robusta*, skeletal and fluid-preserved specimens were examined and compared to those of *M. tuberculata*. Our brief study of these specimens provided no evidence to counter the well-documented distinction of *M. robusta* and *M. tuberculata* at the species level. To supplement these findings with behavioral date, we conducted a multi-faceted study of *M. tuberculata* during November and December 2004. Data from those experiments are presented by Riskin et al. in an accompanying abstract. While capturing live bats for that portion of the study, at Knobs Flat, in the Eglinton Valley (Fiordland National Park, New Zealand), an unusual technique was employed to increase our capture rate. Pairs of mist nets were set up at ground level at several forest sites, with the lower edge of the net extending up from the ground in each case. We alternated between using an Audubon bird caller at each net with periods during which the bird caller was not used. We also alternated between nets (using the bird caller at one net, but not at the other). Captures of *M. tuberculata* only resulted at mist nets where the bird caller was being actively employed. These findings support anecdotal reports suggesting that the sound produced by the bird caller imitates the “singing” calls produced by male *M. tuberculata*. Singing is thought to function in both territorial defense and mate attraction.

Effect of Woodland Restoration on Bat Activity in a Metropolitan Landscape
Debra A. Scott and Stanley D. Gehrt, Ohio State University, Columbus, OH

Urban expansion fragments natural habitats, which can increase wildlife susceptibility to invasive species, predation, disease, and pollution. However, these habitat fragments may be useful for some wildlife species. Currently, restoration efforts, which include invasive/exotic species removal and native vegetation replanting, are underway in several large cities. We assessed restoration efforts and bat activity in various Lake County forest preserves, located in the Chicago metropolitan area. From mid-June to early September in 2004, we used ultrasonic detectors and mist netting to monitor bat activity in nine forest preserves that are in various stages of restoration. We recorded 4,084 bat passes during 2,142 detector hours. The mean number of passes for each forest preserve ranged from 2.45–74.9 passes/site/night. Two sites with high levels of restoration had 74.9 and 62.2 mean number of passes, the highest levels of bat activity of all areas. Four areas with no restoration and three partially restored sites each had means of less than 15 passes/site/night. We also quantified relationships between vegetative structure and species-specific activity. Our results to date suggest bats may respond to some forms of woodland restoration in urban landscapes.

Revisiting the Constraints of Over-wintering by Nectar-feeding Bats in Arizona
Ronnie Sidner, Ecological Consulting and University of Arizona, Tucson, AZ

Winter residence by nectar-feeding bats in Arizona was not supported by the literature in 1990 when I first presented documentation at the NASBR. Both species of nectar-feeding bats, *Leptonycteris curasoae* and *Choeronycteris mexicana*, were reportedly obligate migrators to areas south of the U.S. Rates of nectar consumption and photographs of bats at hummingbird feeders on various dates in winter of 1989–1990, however, showed both *L. curasoae* and *C. mexicana* were indeed present. Their continued presence during observation periods through April 1990 showed that at least some of these bats survived the winter. Nectar-feeding bats have continued to be present in Arizona during the winter since that time. A comparison of body mass of summer-netted *C. mexicana* in southeastern Arizona with those netted at feeders in winters of 19911999 showed that winter bats appear to be in good health. When I posed the question of physiological constraints of cold climates to non-hibernating tropical bats, and in particular, when no forage plants were available, winter roosts in Arizona were unknown. I suggested that nectar-feeding bats might utilize warm roosts in winter such as *Macrotus californicus* does. For the past three years, *C. mexicana* has been using a winter roost inside a rock shelter that provides the thermal constancy required to survive sub-freezing temperatures. Research questions now being addressed are presented.

Phylogeny and Evolution of African Megabats
Nancy B. Simmons, Norberto P. Giannini, Francisca Cunha Almeida, Natalee Stephens, and Rob DeSalle, American Museum of Natural History, New York, NY

Megachiroptera comprises more than 188 species of fruit bats (Pteropodidae). Of these, 41 are found only in Africa or adjacent islands, with 28 restricted to the mainland. Traditional classifications based on morphology suggested that African megabats represent many evolutionary lineages that independently entered and diversified on the African continent. In contrast, recent phylogenetic analyses of gene sequence data indicated that most African megabats might represent a single adaptive radiation. Our own previous studies, based on combined analysis of morphology and published sequences from the *12S*, *16S*, *t-valine*, *cyt b*, and the nuclear c-*mos* oncogene sampled in exemplar taxa, were inconclusive. Ambiguity concerning the relationships of *Eidolon* and the African species of *Rousettus* to other African taxa (and Asian rousettines) made it impossible to determine the number or direction of dispersal events. To address this problem, we have assembled a more comprehensive data set including data from all continental African pteropodid species. Our revised data set includes new gene sequence data from previously unsampled nuclear genes (*RAG1*, *RAG2*, *vWF*) and additional *cyt b* and morphological data, as well as previously published sequences from several mitochondrial genes (*12S*, *16S*, *t-valine*, *cyt b*) and the nuclear c-*mos* oncogene. We analyzed these data in a parsimony analysis using direct optimization under equal weights as implemented in POY. The combination of sources of evidence easily accommodated the morphological and molecular signals, yielding a well-resolved, well-supported phylogeny of African megachiropterans that agrees remarkably well with the current taxonomy of the group. Our new total-evidence phylogeny provides a framework for reexamining patterns of evolution of dietary traits (e.g., nectar feeding) and biogeographic hypotheses (e.g., origins of African megabats) as well as providing unambiguous tests of generic monophyly for all African taxa.

Automatic Classification of Microchiropteran Echolocation Calls: Why the Current Technology is Wrong and What Can be Done about It

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Existing methods for automatic classification of bat calls suffer from two significant limitations: inadequate feature extraction and simplistic modeling. A 10-ms call, sampled at 200 kHz, is represented by 2000 time-domain samples, yet the same call is reduced to less than 10 global feature values (minimum and maximum frequency, duration, shape features) during feature extraction. Such a reduction in representation excludes discriminating information from the call, which increases classification error. Furthermore, modeling is typically implemented using discriminant function analysis (DFA), which uses a single Gaussian kernel to model the probability distribution function of call features. For multi-modal distributions of features (e.g., *Tadarida brasiliensis* uses FM, CF, and FM-CF calls), a uni-modal Gaussian kernel is woefully inadequate. What can be done to address these limitations? A viable solution, developed and refined over the past three decades, comes from automatic speech recognition (ASR). The ASR research community has shifted from expert-driven models to data-driven models (machine learning), primarily because machine learning methods employ superior statistical models that better account for the variations of human speech. The role of experts in the machine learning paradigm of ASR has focused on incorporating knowledge about the production and perception of speech into feature extraction algorithms. We have recently applied two machine learning algorithms to the problem of automatic bat call classification, a hidden Markov model and a Gaussian mixture model, in an experiment using about 3000 hand-labeled calls from five species (*Pipistrellus bodenheimeri*, *Molossus molossus*, *Lasiurus borealis*, *Lasiurus cinereus semotus*, and *Tadarida brasiliensis*). We applied two techniques common in ASR to improve performance: a noise-reduction algorithm called spectral mean subtraction, and the use of temporal derivatives to add local shape information to the feature vectors. We compared the machine learning algorithms to a baseline DFA classifier using a cross-validation experiment in which 50% of the calls were used to train the models and the remaining 50% of the calls were used to test the models. Over 20 trials, both machine learning algorithms classified calls with an accuracy of 99.4 ± 0.2 % while the DFA classified calls with an accuracy of 83.1 ± 1.1% (mean ± SD). The experiment results demonstrate the superior performance of machine learning algorithms, reducing classification errors by an order of magnitude compared to the existing methods. Machine learning methods have the potential to profoundly impact the use of acoustic studies in bat research.

Signal Variation with Climate: Bat Echolocation along Gradients of Sound Absorption
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Signaling systems diverge along environmental gradients affecting signal propagation and reception. Previous studies have focused on how habitat structure interferes with signal propagation through reverberation and reflection. This study tests the hypothesis that climatic variation in signal absorption by the media itself should also drive divergence in signaling systems. Bats of the American Southwest span a climatic gradient of habitats and seasons. As high-frequency sound absorption is higher in hotter habitats, and more humid seasons, I predicted bats echolocating under these conditions would compensate for high absorption by signaling with lower frequencies for longer durations and receiving calls with larger ears. As predicted, bat species that frequented high absorbance habitats produced lower-frequency, longer-duration echolocation calls, at least during the rainy season. In addition, within species, bats changed their echolocation calls between seasons, in general producing lower frequency, longer-duration calls in the more humid rainy season. These patterns were dependent on temperature and humidity gradients, not habitat differences in vegetation structure. Finally, bat species in high absorbance habitats had larger ears. Inter-specific patterns were not independent of phylogeny or body size, suggesting climatic variation in sound absorption at this geographic scale may be sufficient to drive ecological, but not evolutionary, patterns in echolocation. This study highlights the potential importance of climatic gradients, independent of gradients in habitat structure, in influencing the ecology and evolution of signaling systems.

Morphological Diversity of the Genus *Lonchophylla* (Phyllostomidae) in Ecuador and Peru
Sergio Solari, Juan P. Carrera, Carlos Tello, and Robert J. Baker, Texas Tech University, Lubbock, TX; Museo de Historia Natural, UNMSM, Lima, Peru

The tribe Lochophyllini (Phyllostomidae) is a monophyletic group of nectar-feeding bats that includes four genera and thirteen species. Each genus is monotypic except for *Lonchophylla*, with species ranging from Central America to the tropical forests of southeastern Brazil. At least seven species of *Lonchophylla* are known from Ecuador: *L. orcesi*, *L. chocoana*, *L. concava*, *L. hesperia*, *L. robusta*, *L. handleyi*, and *L. thomasi*. The latter four species, and possibly *L. concava*, also occur in Peru. During recent expeditions to the Western and Eastern sides of the Andes Mountains in Ecuador and the northwestern region of Peru, we collected series of specimens referable to this genus. However, species identification is problematic because of recent descriptions of new species (*chocoana*, *orcesi*) and unclear delimitation among taxa, both taxonomic and geographic. Given the large species diversity within these two countries, we assessed the morphological and distributional relationships of species within the genus. We surveyed several discrete characters used in published descriptions or present in the available series, and used selected external and cranio-dental measurements to analyze variation in size among species. Although size alone had been the most useful criterion to discriminate among species, we found that our discrete characters combined with size are more reliable criteria with which to identify species in this region. Distributional records suggest a greater diversity on the western side of the Andes, with restricted ranges for *L. chocoana* and *L. orcesi* in NW Ecuador (the Chocó-Darien region), and *L. hesperia* in SW Ecuador and NW Peru (tropical dry forests). Whereas the range of *L. concava* and *L. robusta* extends from Central America to western Ecuador, that of *L. thomasi* includes most of the tropical forests of South America, on both sides of the Andes. The southern extension of *L. robusta* reaches both sides of the Andes (in Ecuador and Peru) but a similar species, *L. handleyi*, only occurs on the eastern side of the Andes Mountains.

Diet of Two Endemic Nectar-feeding Phyllostomids in Puerto Rico

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This study documents the diet of two endemic species of bat in Puerto Rico—the brown flower bat (*Erophylla sezekorni*) and the Greater Antillean long-tongued bat (*Monophyllus redmani*). Over a five-month period, fecal contents and pollen swabs were collected from over 100 individuals of each species and analyzed. Although both species are considered nectar-feeders, their feeding niches were differentiated. A greater proportion of *M. redmani* (91%) consumed nectar/pollen compared to *E. sezekorni* (50%), but the reverse was true for fruits (22% vs. 85%, respectively). Additionally, ca. 75% of both species included some insects in their diets. Although some common food items were observed between species, the diet of *M. redmani* was more diverse and composed of softer foods. Interspecific differences in diet are consistent with published differences in cranio-dental and wing (flight) characteristics.

The Relative Contributions of Environmental and Contagious Spatial Structure in Determining Species Composition of Paraguayan Bat Assemblages

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Two competing models exist to explain spatial variation in distribution and abundance of organisms and ultimately the composition of species assemblages. The environmental control model suggests that spatially varying environmental characteristics determine spatial structure of species assemblages, whereas the biotic control model suggests that contagious biotic processes such as predation, competition, dispersal, disturbance, and diseases determine such structure. Only recently have quantitative techniques been developed to disentangle the relative effects of both types of structuring mechanisms. We apply such methods to better understand the spatial

structure of 26 bat assemblages distributed throughout Paraguay. Redundancy analyses (RDA) indicated that both environmental and spatial characteristics significantly accounted for the structure of Paraguayan bat assemblages. Partial redundancy analyses (RDA) further indicated that a significant proportion of variation in the structure of these assemblages was accounted for by spatially independent environmental characteristics involving the amount of various vegetational and climatic characteristics associated with sites. Moreover, spatial variation that was independent of environmental characteristics and reflecting contagious biological processes accounted for an additional significant portion of the variation among sites. Such a result suggests both strong species sorting and metacommunity dynamics. These results suggest that both species-environment interactions and the effects of spatially varying biological processes need to be better understood in order to fully comprehend the geographical ecology of bats.

Prevalence, Diversity, and Phylogeny of Malaria Parasites of Bats

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Both Megachiroptera and Microchiroptera have been reported as hosts for malaria parasites, currently classified into four separate genera, *Plasmodium*, *Polychromophilus*, *Dionisia*, and *Hepatocystis*. These classifications have all been based on morphological and/or life history differences in the parasites and little is known about the evolutionary relationships of these genera. Previous phylogenetic work based on mitochondrial *cytochrome b* gene sequences places one species of *Hepatocystis*, from *Cynopterus brachyotis*, within a clade of mammalian *Plasmodium* parasites, however, suggesting that the genus might not be valid. Here I present new phylogenetic results from the malaria parasites infecting *C. brachyotis* and *C. sphinx* from Vietnam using *cytochrome b* and additional mitochondrial, nuclear and apicoplast markers. In addition, I present results from surveys of both microbats and megabats from Bangladesh, Vietnam, Mozambique, and Madagascar using a PCR-based screening method for malaria parasites. To date more than 160 species of the *Plasmodium* parasite have been classified. Data from this study help to resolve the phylogenetic relationships among this diverse group of parasites and adds credence to classifications based on valid morphological characters. Furthermore, the increase in geographical sampling from this study allows for a more complete analysis of phylogenetic relationships among malaria taxa from bats. Portions of malaria phylogenies are supported by previously published chiropteran phylogenies and could be useful in determining the historic proliferation of some of the parasites. It is thought that the arrival of this eukaryote in some areas of the old and new world is a very recent event. Chiropteran phylogenies prove useful in elucidating the parasites progression in different geographic areas and could possibly help in determining what areas hold the best potential for harboring the most primitive forms. This is a critical question considering a basal ancestral form has yet to be discovered. As such, an analysis that includes the maximum number of taxa possible is ideal for understanding the phylogenetic structure of the malaria parasite, and how these taxa group in different geographic regions. The relatively well-known taxonomy of the order Chiroptera makes bats ideal for use in this type of study. These data could, in turn, open up new avenues to area-specific control measures for malaria.

Unique Characteristics of Aerodynamics of Bat Flight: Evidence from Direct Visualization of Patterns of Airflow in the Wakes of Naturally Flying Bats

Sharon Swartz, Ricardo Galvao, Jose Iriarte-Diaz, Emily Israeli, Kevin Middleton, Rachel Roemer, Allyce Sullivan, Xiaodong Tian, and Kenneth Breuer, Brown University, Providence, RI

The interaction of animal wings with the surrounding fluid is similar to, but quite distinct from, that of the wings of human-engineered aircraft. All animal fliers move their complex, deformable wings, via more or less complicated motions, to produce lift and propulsion. To unravel the mechanistic basis of bat flight, it will be necessary to understand the specific contributions of wing shape, dynamic mechanical characteristics of wing tissues, and wing kinematics in generating the aerodynamic forces of bat flight. This requires detailed information regarding the forces that produce flight. Although biomechanicians have been measuring locomotor forces generated by terrestrial vertebrates for several decades, illuminating the mechanisms of fluid force production is far more challenging. One approach is to conceptualize the wake left by a bat's wings and body as a 'footprint' that encapsulates the integrated history of the forces exerted by the bat on the fluid. To visualize and quantify the structure and behavior of the wakes of bats, we employed Particle Image Velocimetry (PIV), a technique developed by experimental fluid dynamicists for empirical study of complex flows. By adapting this technique to slow forward flight in *Cynopterus brachyotis*, we successfully obtained the first detailed, 3D documentation of the structure of bat flight wakes. PIV clearly demonstrates that these wakes differ significantly from those of non-flapping models similar in size and shape to bats, and from those of both flying birds and insects. Bat flight wakes are complex in structure, with many small-scale flow structures in addition to regions of concentrated vorticity. Wake structure changes dynamically over the course of the wingbeat cycle, but does not conform to any published models of flight gaits.

Comparing the Genomes of Three Species of *Carollia* by Documenting the Number of Ribosomal DNA Sites, the Distribution of Genomic DNA, and Accumulation of Repetitive Elements

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In situ hybridization is a technique commonly used in the field of non-human mammalian studies since the early 1980s. This technique utilizes a probe of DNA isolated from a gene or DNA segment of interest and then hybridized to a complementary region of DNA on the chromosome of the target organism. The result is a visual localization of a gene or DNA segment within a particular chromosome or chromosomes. This technique has been utilized to determine the distribution of 28S ribosomal genes in various bat species and also to determine if particular repetitive sequences (LINEs) accumulated on the X chromosome in *Carollia*. *In situ* hybridization has also been used in conjunction with G- and C- banding. G- and C- bands were used quite extensively in the 1980s as a technique to compare chromosomal bands among karyotypes and to reveal possible fusion events. The technique is still in use and has improved with the use of computer software, fluorescent probes, and specialized cameras. Currently, we are utilizing this technique with genomic DNA, ribosomal DNA, and repetitive elements

(LINEs) to detect differences among the karyotypes of three species of *Carollia* (*castanea*, *perspicillata*, and *brevicauda*) whose standard karyotypes are similar. Reciprocal species hybridizations are conducted utilizing genomic DNA. Ribosomal DNA and a LINE element (L1) are also studied. After *in situ* hybridization, the homologous chromosomes of each species are aligned, quantified, and compared for differences between species. Current results indicate that the genomic DNA of *C. castanea* hybridized to specific regions of *C. perspicillata* and *C. brevicauda*. G- bands were prepared from karyotypes that were *in situ* hybridized to standardize position of signal and to detect differences between species. Genomic DNA hybridized to heterochromatic regions and to regions of highly repetitive DNA. These results indicate that there are differences in genome organization between species and that these differences are not easily detectable by examining standard karyotypes.

Do Wind Turbines Generate Ultrasound that May Attract Bats?

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Although audible acoustic emissions from wind turbines have been extensively measured (i.e., frequencies up to 20 kHz), the ultrasound emissions remain uncharacterized for most wind turbines. We performed a basic characterization of ultrasound emissions from a variety of wind turbines, including the 2.5 MW Clipper Liberty and the 1.5 MW NEG Micon wind turbines, to determine whether ultrasound emissions may contribute to attracting bats toward wind turbines with consequential fatalities from rotor strikes. We were particularly interested in characterizing ultrasound emissions from the 1.5 MW NEG Micon turbines because of the documented bat mortality from these turbines operating at the Mountaineer wind farm in West Virginia. This and six other types of turbines measured generated only minor ultrasound above ambient sound levels. The majority of acoustic energy was emitted at audible frequencies, and trailed of rapidly above audible frequencies with a similar profile to that of ambient wind noise. Measured from ground level, 34 m directly below the 1.5 MW NEG Micon wind turbine rotors, these turbines emitted approximately 15, 10, and 5 dB above ambient at 20, 30, and 40 kHz, respectively. Above 50 kHz there was no significant difference from ambient sound levels. We conclude that ultrasound emissions from these wind turbines do not play a significant role in attracting bats.

The iBBAT: A Small Data-logger for Recording Body Temperature

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Bats are among the most thermo-labile of all mammals. Many species and individuals regulate their rate of energy expenditure by adjusting body temperature in response to either the immediate size of their on-board fat reserves or to past or future foraging success. For this reason, monitoring body temperature can tell us much about foraging success and the energetic challenges that individuals face. Here, we present a new self-contained data-logger that allows the measurement of body temperature for bats as small as 10–15 g. The iBBAT is built around the iButton Thermochron technology. The finished package weighs approximately 1.0 g and can store up to 4096 time-marked temperature samples with ±0.13° C precision or 8192 samples at ±0.5° C. The circuit is programmable allowing the user to set both the length of the delay before start-up and sampling rate once running. As an example of one possible application, we present data on the torpor and arousal cycles of *Myotis lucifugus* in Canada and *M. daubentonii* in Poland during the entire hibernation period. Because hibernating vespertilionid bats are extremely sensitive to human disturbance, it is currently impossible to monitor body temperature and infer energy use over the entire winter without some form of remote or data-logging device. The iBBAT now provides a window through which to observe thermoregulatory patterns over extended time frames. Both *M. lucifugus* and *M. daubentonii* undergo regular bouts of deep torpor where body temperature falls to < 5° C. These torpor bouts that last from 12–20 days are punctuated by brief arousals that last from 2–6 hours. Although individuals do differ in their patterns, there are no clear seasonal trends in the torpor-arousal cycles.

Foraging Movements and Day Roost Selection of Female Epauletted Fruit Bats in Kruger National Park, South Africa

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Based on radiotelemetry data from 21 individuals, we report on the home range, core-use area, and long-axis across home of female *Epomophorus wahlbergi* during the dry season in Kruger National Park (KNP). Nightly movements of up to 16 km were recorded between day roosts and feeding trees. The size of home range is compared using minimum convex polygons and fixed kernel methodologies. Epauletted bats at Skukuza in southern KNP exclusively sheltered under thatch roofs at the tourist camp in groups of one to sixty bats. At the Shingwedzi River drainage in northern KNP, epauletted bats roosted generally near the banks or flood plains of rivers in a variety of small trees including *Combretum*, *Maytenus*, and *Colophospermum*. Group size within day roosts at Shingwedzi was one to six bats and these bats always selected perches less than 4 m above ground. A single individual was radio-collared in two years and demonstrated that "home range" is fluid over time in response to the tempo-spatial array of individual fruiting trees. The dry season diet of *Epomophorus wahlbergi* is dominated by fruits of *Ficus sycomorus*.

Ecology of Parasitism on Brazilian Free-tail Bats (*Tadarida brasiliensis*)

Amy S. Turmelle, University of Tennessee, Knoxville, TN

This study examines variation in ectoparasite prevalence in natural populations of the Brazilian free-tail bat (*Tadarida brasiliensis*) in south-central Texas. Brazilian free-tail bats are known to colonize both man-made and natural roosts in Texas from mid-March to late October. To date, few studies address the health of *T. brasiliensis* populations in different roosts. Recently, research has begun to examine levels of stress, disease, parasitism, and immune function in *T. brasiliensis*, among and within different roosts in south-central Texas. This study focuses on two major questions: Does the rate of parasitism (i.e., prevalence) of *T. brasiliensis* vary across different roosts? Does prevalence change within a site across a season? Both questions require information on roosting conditions, variables such as an individual's age, gender, and reproductive condition, and how these variables change with time. Parasitism is measured with respect to both larger (e.g., fleas, ticks, batflies) and smaller (e.g., mites) ectoparasites. Larger ectoparasites were removed by hand with the aid of forceps. Smaller ectoparasites, present on the patagium of the bat, were photographed and parasite loads were quantified from the digital images. I compare levels of parasitism across four sites, consisting of two caves and two bridges, from early May until late August, covering periods of pregnancy, lactation, and post-lactation. Each site was visited a total of six times independently, and over 600 bats were sampled. Preliminary data suggest significant differences in ectoparasite prevalence across sites. Differences between estimates of prevalence made from larger and smaller ectoparasites will be discussed in the context of ecological and biological variables.

Preliminary Report of the Roosting Habits of the Eastern Small-footed Bat, *Myotis leibii*, in New Hampshire

Jacques Pierre Veilleux, Franklin Pierce College, Rindge, NH

The eastern small-footed bat, *Myotis leibii* (Chiroptera: Vespertilionidae), is considered one of the rarest bat species in North America. As such, extremely few data are available that describe the summer roosting ecology of this species. A small population of eastern small-footed bats was recently discovered in southwestern New Hampshire. During the 2005 summer field season, I initiated a study that will examine various aspects of the biology of this population, including reproductive patterns and roosting habits/roost selection. This talk will present preliminary data on this species, reproductive patterns and roosting habits that were collected during this first research season. Research was conducted at the Surry Mountain Lake Dam (SMLD) located in Surry, Cheshire County, New Hampshire. The SMLD is managed by the U.S. Army Corps of Engineers. Roosting habitat for eastern small-footed bats mainly consists of a large east/southeast facing rock wall and two (one north and one south facing) ~600 m long by ~ 70 m wide rock jumble slopes that comprise the dam proper. Twelve eastern small-footed bats were radio-tagged, including eight pregnant females, three lactating females, and one male. Twenty-seven roosts were located of which twenty were verified by visual observation of bats in the roost or observing bats as they emerged in the evening. Six individuals roosted exclusively within the south facing rock jumble slope, five individuals roosted on the large rock wall and/or nearby structures, and one individual (the adult male) roosted within the south facing slope and within a barn. Additional data will be included as field work currently continues.

Ecological and Life History Correlates of Ectoparasite Species Richness in Bats

Maarten J. Vonhof and Kate E. Jones, Western Michigan University, Kalamazoo, MI; Institute of Zoology, Zoological Society of London, Regents Park, London, UK

Understanding the factors determining species richness of parasite communities is an important problem in ecology, as most animal species are parasites, and parasitic organisms have the potential to profoundly affect the structure and stability of natural communities. Many host traits have been shown to correlate with parasite species richness, but few studies have evaluated a large number of predictors simultaneously. We have initiated a study to examine the ecological, life history, and morphological correlates of parasite species richness in bats. As the second largest group of mammals encompassing approximately 1100 species, bats provide habitat to a tremendous diversity of ectoparasites, including 17 families of mites and ticks and 8 families of insects. We are in the process of compiling a comprehensive database of all host-parasite records from bats in the literature since 1950, and have completed ~ two-thirds of ectoparasite families. Here we present the results of preliminary analyses on insect ectoparasites, including bugs (Cimicidae and Polyctenidae), fleas (mainly Ischnopsyllidae), batflies (Nycteribiidae, Streblidae, and Mystacinobiidae), and earwigs (Arixeniidae and Forficulina). Using independent contrasts to control for the effects of phylogeny, we examine the specific ecological, life history, and morphological features of bats that result in observed patterns of insect parasite species richness.

Conservation and Science at Lubee Bat Conservancy

Allyson L. Walsh and Dana LeBlanc, Lubee Bat Conservancy, Gainesville, FL

Lubee Bat Conservancy is an international nonprofit organization dedicated to protecting biological diversity through fruit and nectar bat conservation. At the Lubee Bat Conservancy, we have a 16-yr history of coordinating worldwide conservation, research, and education efforts aimed at protecting and enhancing populations and habitats of fruit and nectar bats. We work with an international team of conservation scientists, educators, and zoological institutions, linking field conservation with our premier Center for Tropical Bat Research and Conservation to deliver new scientific findings and conservation initiatives with long-term impact on fruit and nectar bat conservation. The Conservancy maintains a living animal collection of fruit and nectar bats, supports field conservation science programs, and provides research, education, and training opportunities for school children and field professionals. Lubee Bat Conservancy is a recognized global leader in successful zoo husbandry for endangered bat species and effective bat conservation science, with over 110 scientific publications on reproduction, husbandry, energetics, physiology, behavior, ecology, evolution, and conservation topics. This poster discusses some of our more current research and conservation science programs, with the aim of stimulating new ideas and future research at our center.

Vertical Stratification and Seasonal Patterns of Bats in a Neotropical Lowland Rainforest and the Influence of Mist Netting Biases

Christa D. Weise and Elisabeth K.V. Kalko, University of New Mexico, Albuquerque, NM; University of Ulm, Germany; Smithsonian Tropical Research Institute, Panama City, Panama

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 studied the vertical stratification, species composition and seasonality of abundance of the Neotropical bat community on Barro Colorado Island, Panama, using high net walls and ground level mist 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, whereas some species are almost exclusively captured within a small vertical range. In this forest the low understory showed the least bat activity, whereas the sub-canopy was utilized most. A significant seasonal shift of foraging stratum was not found for any of the studied species, but several species showed extreme seasonality in their occurrence or abundance. Especially high-flying forest bat species (*Centurio senex*, *Phyllostomus discolor*) showed clear seasonality. Mist netting is a commonly used method for sampling bat communities, although it is assumed that there are disparate netting biases for different bat species because of the behavior, foraging strategy, echolocation skills, and spatial memory of the bats as well as environmental factors. Although some species appear to be fairly well sampled by mist netting, others seem to be underrepresented, which can have a significant effect on the evaluation of data on a community level. Preliminary results of mist netting bias on the interpretation of the bat abundance and seasonality data will be discussed.

Interpreting Bat Echolocation for Museum Visitors: The Making Sense of Cave Life Gallery at the Oakland Museum of California

Dorris Welch and Dana Neitzel, Oakland Museum of California, Oakland, CA

The Cave Life Gallery at the Oakland Museum of California presents a series of interactive exhibits designed to demonstrate sensory adaptations of bats and other animals living in a dark cave environment. Our exhibit development challenge here was to provide background content—basically, sound physics—that would allow visitors to build an understanding of how echolocation works. To accomplish this, we created a combination of interactives and exhibit panels that interpret vibration, high frequency, and echoes, guiding the visitor into the topic of echolocation. The Seeing with Sound exhibits explores bat echolocation with a sound vibration box, a high frequency comparative hearing interactive, and an echolocation listening station. Interpretive challenges in developing the Cave Life Gallery included: helping visitors to comprehend an environment of total darkness where sight is not an option; demonstrating the need for non-optical senses in the darkness of a cave; and interpreting echolocation. We conducted remedial evaluation of the Cave Life Gallery with cued visitor family groups to determine the effectiveness of the interactive exhibit components for general audiences. We wanted to learn how successful we were in our interpretation of cave animals and sensory adaptations, and to determine instructional effectiveness of the interactives.

In Search of Simple Characters to Distinguish *Myotis lucifugus* and *Myotis yumanensis* in the Field

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The ability to accurately identify species is a prerequisite for accurate assessment of biodiversity. In northwestern North America the two sympatric species, *Myotis lucifugus* and *M. yumanensis* are difficult to distinguish based on external morphology and additional tools must be employed to identify individuals in hand. In recent years, it has been shown that it is relatively easy to distinguish these species via DNA analysis. However, many workers do not have ready access to genetic laboratories or the funds necessary to complete molecular analyses allowing unambiguous species identification. At least three previous efforts have attempted to identify characteristics that can be measured in the field to reliably discriminate between the species. However, inference from these studies was limited because of the restricted geographic range over which individuals with linked genetic, morphology, and echolocation data had been obtained. We obtained a sample of over 100 individuals of each species captured throughout northern California, Oregon, and Washington for which we have linked genetic, morphology, and echolocation data. We used these data to derive a simple algorithm for discriminating the two species based on characters that can be easily and reliably measured in the field. Specifically, we develop a sex-specific model to determine threshold values for forearm length and characteristic frequency of echolocation calls that can be used to discriminate between *M. lucifugus* and *M. yumanensis* at specified levels of confidence. Results of our model will allow biologists in the region to understand the conditions under which individuals captured in the field can be identified in the field or to screen them prior to submission for DNA analysis. We will challenge the model with data from across the inter-mountain west to determine geographic range of its application.

Are Red Bats (*Lasiurus borealis*) Declining in Southern Michigan?

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We have evidence suggesting that populations of the red bat (*Lasiurus borealis*) have declined over the past few decades in southern Lower Michigan. Regional, multi-year surveys of bats were completed during the summers of 1978–1979 and again in 2004–2005. In addition, detailed surveys were performed at two specific sites. Upland habitats at the Fort Custer Military Training Center in Calhoun and Kalamazoo counties were surveyed in 1993 and 2005, whereas netting over the Thornapple River in Eaton County occurred in 1978–1979 and 1993–1994. Total number of bats that were captured in each survey varied from 116–821, and number of net-nights ranged from about 40 to 110. Red bats represented 20% of the catch in the regional survey during 1978–1979, but only 11% in 2004–2005; 44% at Fort Custer in 1993, but 21% in 2005; and 9% over the Thornapple River in 1978–1979, but 1% in 1993–1995.

Prenatal Development and Skeletogenesis in the Angola Free-tailed Bat (*Tadarida condylura*)

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Few data are available on prenatal development for bats. We investigated developmental changes in gross anatomy and skeletogenesis using ten fetuses of the Angola free-tailed bat, *Tadarida condylura*. We measured crown-rump length, skull length, and length of forearm to the 0.01 mm with digital calipers. The mass of each embryo was measured to the 0.01 g using a digital pan-scale. Preserved specimens were soaked in water for 30 minutes to loosen tissue so that the right wing could be extended and pinned onto graph paper. Photomicrographs were taken using an Olympus dissection microscope interfaced with a digital camera and wing areas (mm^2) were calculated from the images using Sigma-Scan Measurement Software. Length of skull was used as the independent variable for growth plots. Changes in crown-rump length and body mass significantly regressed with skull growth ($r^2 = 0.888$, $p < 0.05$; $r^2 = 0.799$, $p < 0.05$, respectively) as did length of forearm ($r^2 = 0.899$, $p < 0.05$). Changes in wing area, when plotted against body mass, showed a significant regression ($r^2 = 0.959$, $p < 0.05$) suggesting that wing area and body weight increase in tandem in this species during fetal development. We quantified skeletal development by differentially staining fetuses with alcian blue to show condrification, alizarine red to show calcification, and cleared the specimens using trypsin and glycerin baths. From this analysis we were able to show patterns of osteogenesis for this species.

The Ecomorphology and Biogeography of *Carollia* (Phyllostomidae)

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The short-tailed fruit bats (Phyllostomidae: *Carollia*), which range from central Mexico to northern Argentina, traditionally have been treated as a single ecological entity in examinations of plant-animal interactions and Neotropical bat community ecology. To explore the validity of this generalization as part of a larger study of species coexistence, we analyzed skull morphology and bioclimatic preferences for the currently recognized species and subspecies within the genus. Analyses based on museum specimens and the localities at which they were collected indicate significant morphological differentiation consistent with character displacement and that the suite of preferred climatic characteristics differs among the various focal taxa. Furthermore, we used a genetic algorithm for rule-set prediction (GARP) modeling procedure to describe niche characteristics used to predict areas throughout Latin America where each taxon might occur. Comparing these results to actual taxon ranges highlights potential cases of competitive exclusion and is useful in identifying biogeographic features responsible for hindering dispersal and establishment. Our analyses indicate that the various species and subspecies of *Carollia* deserve to be recognized as distinct ecological entities and point to possible mechanisms that facilitate coexistence among congeneric taxa

Vaccine-induced Immunity to Rabies Virus in a Captive Colony of Pallid Bats (*Antrozous pallidus*)

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Most mammals in a laboratory research setting are managed in such a way as to minimize the risk of exposure to viruses. Bats, like all mammals, are susceptible to the rabies virus. Maintenance of captive bat research colonies provides many challenges. Beyond the task of maintaining the health of the animals, researchers must ensure the safety of personnel in contact with captured wild bats and protect the colony from other bats that might be introduced to the colony. Chief among concerns is the zoonotic, viral disease rabies. This paper describes one approach to managing these concerns. Two colonies of wild caught pallid bats, *Antrozous pallidus*, which were maintained independently in quarantine for six months after capture, were tested for rabies virus antibody using the rapid fluorescent focus inhibition test (RFFIT). Bats that tested seronegative (titer less than 1:50) were vaccinated with a commercial rabies vaccine and then retested in four weeks for immunological response to vaccination. Ten of the thirteen bats in the first colony seroconverted after the initial vaccination, post seroconversion titers ranged 1:130 to 1:70,000. Two of the three remaining bats from this colony seroconverted after a booster inoculation eight weeks after the initial vaccination, post seroconversion titers ranged 1:430 to 1:540. Ten of twelve bats in the second colony seroconverted after the initial inoculation, post seroconversion titers ranged 1:170 to 1:950. This is the first known account that addresses naïve rabies titer and response to vaccination in wild caught insectivorous bats. Stimulation of rabies virus antibody by vaccination has been historically accepted as the best means of animal and human protection against viral infection and spread. This is another defense we have used in an attempt to provide the safest possible environment for researchers and staff working with these wild caught animals.

A Coprogenetic Method for *ex situ,* Non-invasive Species Identification from Mixed-species Samples Using Microarray Technology: An Overview of the Technology and its Practical Application

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With increasing interest in the conservation and management of bat populations both globally and within North America, it is becoming increasingly important to be able to accurately identify the species of interest. Furthermore, as we become more and more aware of the impact of research activities on the behavior of bats, less- or non-invasive techniques for assessing species presence, such as sampling feces inside roosts and collecting membrane punches instead of specimens, are becoming more desirable and common. Field surveys associated with species identification, conservation, and habitat management can be labor intensive, expensive, and inadequate, and we need to look to less invasive and more efficient techniques to achieve our research and management goals. The use of genetic markers may provide an alternate source of useful characters to aid in species discrimination, and is particularly useful in groups of organisms exhibiting low morphological diversity, or where morphological identification is simply not possible because of practical, methodological, or conservation considerations (e.g., endangered species, non-invasive sampling). DNA microarrays, a series of nucleic acid targets immobilized on a solid substrate such as a glass slide or silicon chip, allow for the simultaneous analysis of thousands of molecular markers in a single experiment, versus the traditional approach of amplifying single, large gene targets. Their high data generation capacity has obvious and significant time and resource advantages. The sensitivity of microarrays allows for the detection of subtle differences that are much harder to detect with other molecular methods, making them ideally suited for use with non-invasively collected samples, such as hair and feces, with low DNA content. The use of microarray technology will allow for relatively low cost, high-throughput screening of scat or tissue-based samples for accurate species identification of all bat species found in the continental United States. This technology will be a key development for all management, compliance, and research efforts associated with listed (endangered, threatened, or vulnerable) bat species at the federal and state levels. Additionally, microarray technology represents a substantial cost savings, and potentially a much broader ability to test quantities of guano from natural and artificial roosts, as compared to individual pellet testing when species presence or absence from a given roosts is of interest.

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Report on the

35th Annual North American Symposium on Bat Research

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The 35th Annual North American Symposium on Bat Research was held at the Holiday Inn Capitol Plaza in Sacramento, California, 19-22 October 2005. Winston Lancaster (California State University Sacramento) served as the local host. Three hundred and fifty registered participants attended the three-day scientific conference, making this the largest non-international NASBR meeting ever held. In addition to the regular participants, there were approximately 35 local educators who attended the special 10th Anniversary Teacher Workshop on Saturday morning.

Most of the meeting participants (60%) were affiliated with academic/research institutions; 21.0% were from private business or private consulting groups; 14.0% were from federal or state government agencies; ~1% were from non-governmental zoos and parks; and ~4% were individuals who attended simply because they were interested in bats. More than a third (39%) of the meeting participants were students. The majority of NASBR participants were from North America: 85.4% from the United States, 9.1% from Canada, 1.7% from Mexico, 1.4% from Puerto Rico, and 0.6% from Costa Rica. There also were participants from Europe (United Kingdom, 0.6%; Germany, 0.3%; and Italy, 0.3%), Brazil (0.3%), and Australia (0.3%).

One hundred and fifty-one scientific papers were presented at the Sacramento meeting, not counting the special presentations given in two non-scientific sessions (six during the special evening “Innovative Teaching Techniques” session and eight during the Saturday morning workshop for local teachers). Of the 151 scientific papers presented, 98 were platform presentations and 53 were poster presentations. Seventeen student platform papers were presented in a plenary Student Competition Session on Thursday. The rest of the platform papers were presented in concurrent sessions that began on Friday morning and continued through Saturday afternoon. Fifty-three posters, eleven of which were entered in the Student Poster Competition, were presented during the Thursday afternoon Poster Session.

Graduate and undergraduate students were invited to enter their platform or poster papers in a competition that judged the scientific merits of their research. A special committee headed by Frank Bonaccorso judged 17 student platform papers and 11 student poster presentations. Six cash prizes of $250 each were presented at the Saturday evening banquet. The award winners were:

Outstanding platform papers

Marie-Helene Pitre (Sherbrooke University, Québec) received the Bat Conservation International Award;

Melissa Andre Neubaum (Colorado State University, Fort Collins, CO) received the *Bat Research News* Award;

Susan W. Murray (Boston University, Boston, MA) received the Karl F. Koopman Award;

Kirsten M. Bohn (University of Maryland, College Park, MD) received the Lubee Bat Conservancy Award

Outstanding poster presentations

Wiebke Pflaesterer (Universitaet Tuebingen, Germany) received the Basically Bats Wildlife Conservation Society Award;

Matthew E. Grilliot (Auburn University, Auburn, AL) received the Speleobooks Award

Generous monetary donations from Merlin Tuttle of Bat Conservation International, Margaret Griffiths of *Bat Research News*, Roger Haagenson, 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.

During the banquet, lifetime members of the NASBR were recognized. This honorific membership, nominations for which are made by individual NASBR members, is conferred by the Board of Directors “in recognition of a long and distinguished career in bat research or education about bats.” G. Roy Horst, who was named a Lifetime Member of the Society in 2003, was presented with a plaque commemorating his lifetime membership. The final highlight of the evening was the conferment of another Lifetime Membership. John R. Winkelmann (Gettysburg College, Gettysburg, PA) was named as the third Lifetime Member of the NASBR, and was presented with a plaque commemorating his lifetime membership. The three Lifetime Members of the NASBR are: Jim Findley (1997), G. Roy Horst (2003), and John Winkelmann (2005).

Approximately 60 people attended a special Friday evening session entitled “Innovative Techniques in Teaching,” which was organized by M. Brock Fenton. Five scheduled presentations and one impromptu presentation were given. The theme of the session was reporting initiatives that participants have taken in the area of education, several of which related to using bats in those initiatives. The goal of this session was to share ideas and information about effective teaching strategies, and those who attended felt it was a very helpful session.

Pat Morton of Texas Parks and Wildlife once again organized a special bat education workshop on Saturday morning of the conference. Sacramento-area educators attended the workshop, as well as many NASBR members. This was the tenth 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. Pat and I also thank Bat Conservation International, *Bat Research News*, California Native Bat Conservancy, Lubee Bat Conservancy, Organization for Bat Conservation, Speleobooks, and Texas Parks and Wildlife for their generous donations to support the workshop.

I thank the 2004-2005 Board of Directors (Robert Barclay, Frank Bonaccorso, Mark Brigham, Mary Kay Clark, Betsy Dumont, Tom Griffiths, Michael Herder, Roy Horst, Winston Lancaster, Arnulfo Moreno, and Nancy Simmons) and the Student Observers to the Board (Annie Tibbels and Heather York) for their help and support this year. I also thank Fiona Reid for sharing her time and talent designing the 35th NASBR logo, Heather Johnson for sharing her photographs (logo background), and Al Kisner for his help with registration once again this year.

Additionally, my sincerest gratitude and special thanks go to Emilee Bocker, Andy Hall, Tom Griffiths, and Winston Lancaster for all their help and hard work in making the 35th NASBR a very memorable and successful meeting. And on behalf of the entire NASBR membership, many, many thanks from all of us to Roy, our “founding father,” and of course, to the bats!

Finally, I extend my sincerest thanks and appreciation to you, the entire NASBR membership, for making the annual NASBR meetings increasingly successful and very memorable. I have enjoyed working with all of you over the past ten years, and I wish you all the very, very best.

Tenth Anniversary of the NASBR Teacher's Workshop

Pat Morton, Workshop Organizer

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In 1996, at the 26th Annual North American Symposium on Bat Research (NASBR) in Bloomington, Illinois, the society held its first teacher's workshop, beginning a tradition of outreach at our annual meeting. The society has now embraced this event as a community service for the city where NASBR meets, and over the past 10 years, hundreds of local educators have been introduced to state/regional bats and their ecology, behavior, and conservation needs. Donations provided by sponsors of these workshops have allowed participants to return to their community not only with an increased knowledge of bats but also with a substantial number of educational tools, such as books, posters, curricula, and videos.

At the recent 35th Annual NASBR in Sacramento, our presenters once again generously took time away from their participation in the scientific aspects of NASBR to help educate the public. Patricia Brown-Berry (University of California, Los Angeles, and Brown-Berry Consulting) provided an introduction to the bats of California, and Stephanie Remington (California bat expert and educator) followed up with an exercise on bat identification that used a key and a collection of study skins provided by NASBR local host, Winston Lancaster. Stephen Burnett (Clayton State University) made a fascinating presentation on teaching bat echolocation, and Rob Mies (Organization for Bat Conservation) helped educators learn how to motivate an audience about bats and bat conservation. Finally, two California educators and rehabilitators—Dharma Webber (California Native Bat Conservancy) and Patricia Winters (Wings in the Night Education Programs)—brought out live bats and used them to build on information presented by other speakers (anatomy, behavior, echolocation, etc.). This was easier said than done due to very strict permitting and demonstration requirements dictated by California law. In addition to our presenters, two other people must be acknowledged. Robin Whittall (Sacramento Zoo) was the local liaison for the workshop, helping to promote the workshop and managing the registration process, and Margaret Griffiths (Illinois Wesleyan University) arranged all logistics at the hotel (meeting room, audio-visual equipment, and refreshments).

The annual workshop cannot be done without the many generous sponsors, many of whom have been supporters for the full 10 years! I thank the following organizations for helping to make the teacher's workshop at Sacramento a success, as well as a permanent part of the annual meeting: Bat Conservation International, *Bat Research News*, California Native Bat Conservancy, Lubee Bat Conservancy, NASBR, Organization for Bat Conservation, Speleobooks, and Texas Parks and Wildlife Department.

This year's workshop in Sacramento was certainly one of the best and was filled to overflowing during the six hours of presentations. I hope that those readers who plan to attend the 2006 NASBR meeting will stop by and visit the Saturday workshop so that they may become acquainted with NASBR's effort to inform and engage local educators.

RECENT LITERATURE

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

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ANNOUNCEMENTS

The Bernardo Villa Student Award

The North American Symposium on Bat Research (NASBR), wishing to encourage dialogue between Mexico and the United States, has recently established the Bernardo Villa Student Award for a Mexican graduate or undergraduate student who is doing outstanding chiropteran research. The monetary prize associated with the award will help the recipient attend the annual NASBR meeting to present his/her work on some aspect of bat biology.

The Bernardo Villa Student Award includes: transportation, hotel, and symposium registration fee.

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Please send the above requested documents to:

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Premio Bernardo Villa a la investigación en Murciélagos

El premio Bernardo Villa es un reconocimiento que otorga la “North American Symposium on Bat Research” para que estudiantes de Licenciatura y/o Postgrado presenten el resultado de sus investigaciones sobre murciélagos en el Simposio anual de la Sociedad.

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Ø Breve descripción del trabajo en español (máximo cuatro cuartillas), incluyendo titulo, autor(es), resumen, introducción, método, resultados, discusiones y conclusiones, y literatura citada. Se recomienda incluir tablas y figuras anexas.

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Please pass on the above information (in English or Spanish) to all interested individuals. Thank you!

Graduate Assistants – May 2006

Two Graduate Assistants needed for 2-year study of bats in southeastern Michigan, beginning about 15 May 2006. Candidates must have a bachelor's degree in a biological field (or be nearing completion of the degree) and meet requirements of the university and the department for admission into our master's program. Work will involve mist-netting, radio-tracking, behavioral observations, and dietary analyses, with an emphasis on evening bats and Indiana bats. During summer, successful candidates will receive a stipend and reimbursement of field expenses, and during the academic year, they will be offered positions as graduate teaching assistants in the Department of Biology. Send statement of interest, resume, and names and e-mail addresses of two references to:

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