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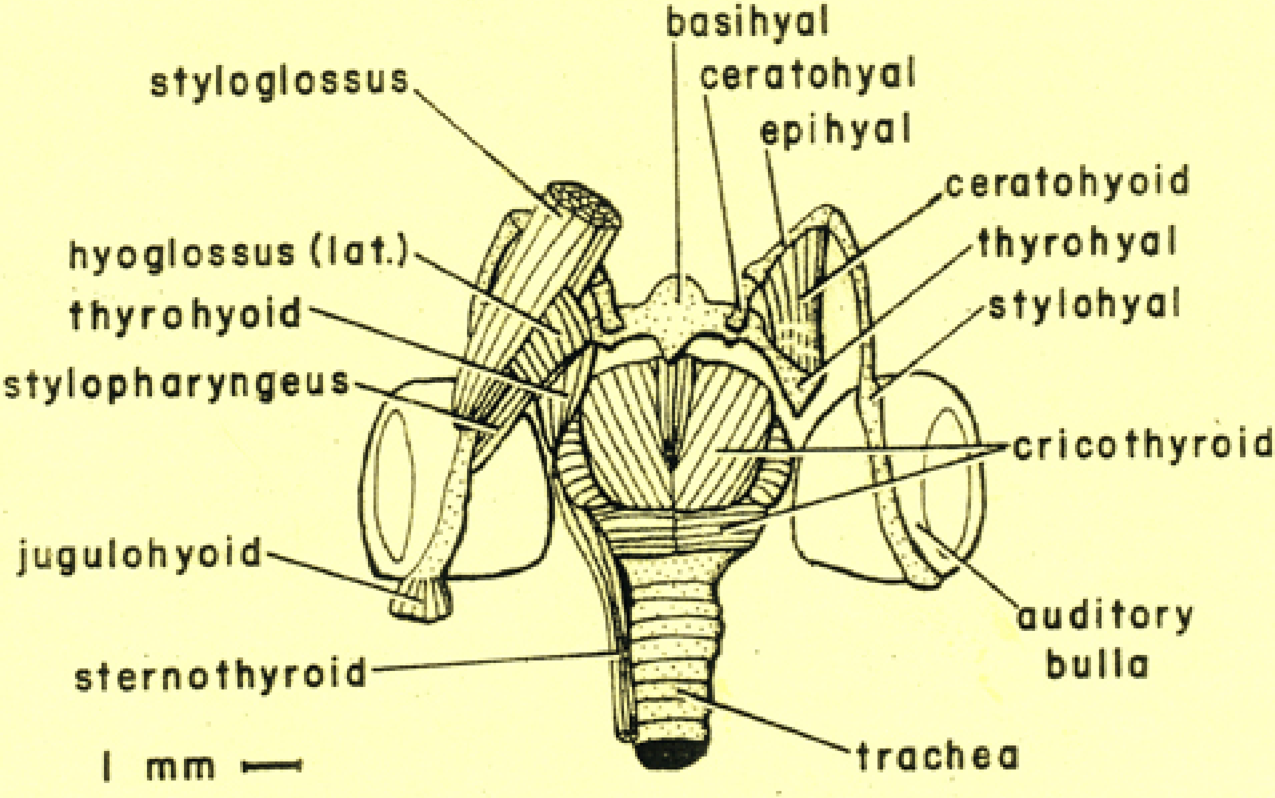

VOLUME 47: No. 1

Spring 2006

BAT RESEARCH NEWS

Table of Contents for Volume 47, 2006

Volume 47: Number 1, Spring 2006

Volume 47: Number 2, Summer 2006

BAT RESEARCH NEWS

Table of Contents for Volume 47, 2006

(cont.)

Volume 47: Number 3, Fall 2006

Volume 47: Number 4, Winter 2006

BAT RESEARCH NEWS

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Aspects of Migration by the Endangered Indiana Bat, *Myotis sodalis*

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Introduction

Many temperate bats migrate several hundred kilometers from their summer roosts to winter hibernacula, a journey that is both energetically costly and dangerous due to increased exposure to weather and predators (Fleming and Eby, 2003). During hibernation, most bats require specific environmental conditions to minimize energy expenditure, and consequently, they often hibernate in caves, which are restricted to specific geological regions (e.g., Culver et al., 1999). Because time and energy is required to migrate, the possible distance between summer roosts and winter hibernacula theoretically is limited, and thus, knowledge of migratory abilities may be useful in predicting the geographic range of a species. Knowledge of migratory patterns also is essential for conservation of an endangered species, such as the Indiana bat (*Myotis sodalis*), because managers must ensure the existence of appropriate shelter and food for the animal on both the summer and winter range, as well as along the migratory route. In this report, we describe new records of long-distance migration by the Indiana bat, comment on the time needed for such migrations, and speculate on the relationship between the location of hibernacula and of summer roosts.

New Migratory Records

On 27 May 2004, we captured five adult female Indiana bats near their maternity trees, ca. 3 km SE of Norvell, Jackson Co., Michigan, and placed a uniquely numbered band on the forearm of each animal (Winhold et al., 2005). Three of the five bats eventually were recovered while hibernating during the following winter (C, D, and F in Fig. 1). The first bat was recovered in Jug Hole Cave, Harrison Co., Indiana, on 22 January 2005. The second female was found in Cave Branch Cave, Menifee Co., Kentucky, on 27 January 2005, and the third Indiana bat was recovered on 3 February 2005 in Colossal Cave, in Mammoth Cave National Park, Edmonson Co., Kentucky. These bats were hibernating in caves that were ca. 476, 465, and 575 km, respectively, from their summer range.

Distance of Migration

Based on early studies by W. H. Davis (in litt.; Kurta, 1980) in the 1960s and our own fieldwork since 1995 (Kurta and Murray, 2002; this study), we now know of 12 banded Indiana bats that have made spring or fall migrations between Michigan and Indiana or Kentucky. The distance covered by these migrations ranges from 410 to 575 km, with a mean of 477 ± 15 (*SE*) km. These distances are some of the longest migrations on record for any *Myotis* in North America. Tuttle (1976) indicates that some gray bats (*M. grisescens*) moved 525 km from a summer roost in Florida to a hibernation site in Tennessee, whereas Humphrey and Cope (1976) mentioned a 455-km migration by a little brown bat (*M. lucifugus*) from a maternity site in northern Indiana to a cave in southern Kentucky. For other North American species of *Myotis*, the maximum recorded distance is less than 100

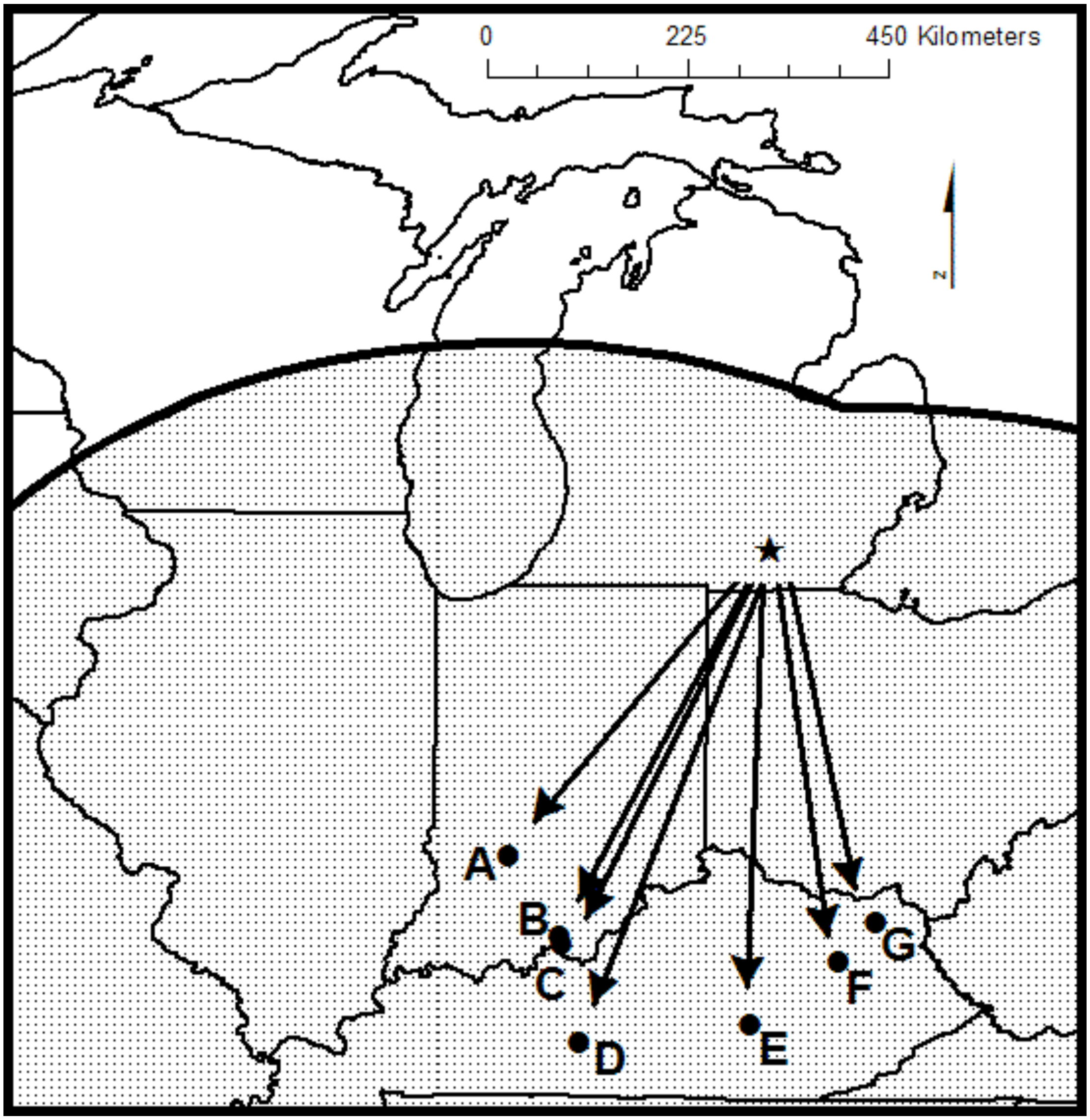

Figure 1. Migration of Indiana bats that were banded on their summer range near Norvell, Jackson Co., Michigan (star), and later found hibernating in caves in Indiana and Kentucky—A) Ray's Cave; B) Batwing Cave; C) Jug Hole Cave; D) Colossal Cave; E) Waterfall Cave; F) Cave Branch Cave; and G) Bat Cave. Curved line indicates 575-km limit from any of the hibernacula, and stippled area suggests the extent of summer range of the Indiana bat in the Upper Midwest, based on this maximum migration distance.

km. These include southeastern bats, *M. austroriparius*, 72 km (Rice, 1957); cave bats, *M. velifer*, 59 km (Dunnigan and Fitch, 1967); northern long-eared bats, *M. septentrionalis*, 56 km (Nagorsen and Brigham, 1993); and small-footed bats, *M. leibii*, 19 km (Best and Jennings, 1997). Previously published records for long-distance migration by Indiana bats were 520 km (Gardner and Cook, 2002) and 532 km (Kurta and Murray, 2002).

Theoretically, the summer range of the Indiana bat could include all geographic areas that are within the maximum migratory distance (575 km) of their hibernacula. However, there are substantial parts of Michigan, northern Illinois, southern Wisconsin, and southern Ontario that are located less than 575 km from major hibernacula in Indiana and Kentucky (Fig. 1), yet there are no records of Indiana bats from these regions (Gardner and Cook, 2002). Some of these areas, such as parts of the central Lower Peninsula of Michigan and most of Wisconsin probably are too cold in summer for this essentially southern species (Brack et al., 2002). However, we suspect that Indiana bats eventually will be found in areas of suitable habitat in some of these northern regions, especially along the western coast of Michigan, where Lake Michigan has a substantial moderating effect on the climate, and perhaps in extreme southern Ontario, where Lake St. Clair and Lake Erie help create some of the mildest weather in Canada (Keen, 1993).

Time Needed for Migration

Migration is a dangerous undertaking (Fleming and Eby, 2003), and animals may attempt to minimize the time spent en route. Total time that is required for any migration is a function of both flight speed and the nightly duration of migratory activity (Table 1). Indiana bats bearing radio transmitters recently were followed by aircraft during their spring migration in New York and Pennsylvania, and these bats usually maintained flight velocities between ca. 13 and 20 km/h while migrating, with one bat perhaps traveling at 24 km/h (Butchkoski and Turner, 2005; C. Herzog, in litt.). A flight speed of 20 km/h is similar to that measured by Patterson and Hardin (1969) for Indiana bats released in an open field and close to the velocity predicted for an 8-g bat by the allometric equation of Norberg and Rayner (1987). Time spent in migratory flight during any one night by the bats in New York and Pennsylvania typically was only 2–3 h, with a maximum of 5.5 h (Butchkoski and Turner, 2005; C. Herzog, in litt.). Most of these bats, however, migrated a total of only 30–50 km between winter and summer quarters, i.e., distances that could be completely covered in only a few hours; consequently, the durations of their nightly flights may underestimate the capabilities of the species. A number of aerial insectivorous bats, including the Indiana bat, spend an average of 6–7 h each night in foraging flight in summer, with some individuals foraging for more than 8 hours (Murray and Kurta, 2004; S. W. Murray, in litt.). This suggests that migratory flights of 8 h/night might be possible, although such prolonged bouts of migratory activity would leave little time for foraging or locating temporary roosts.

To estimate the duration of migration between Michigan and the karst regions of Indiana and Kentucky, we assumed that the bats flew the average 477 km in a straight line, for either 4 or 8 hours each night, at a speed of 13 or 20 km/h, with no multi-night stopovers at any location (but see Humphrey and Cope, 1976). Under these assumptions,

Table 1. Predicted duration of a 477-km migration by an Indiana bat, based on different velocities of migratory flight and nightly durations of flight.

Velocity of migratory flight (km/h)	***Duration of total migration (days)***	
	4 h of migratory flight per night	**8 h of migratory flight per night**
13	9.2	4.6
16.5	7.3	3.6
20	6.0	3.0

the time needed for the average 477-km migration is 3.0–9.2 days (Table 1). Indiana bats that migrate over the maximum recorded distance (575 km) can likely complete the journey in only 7–11 days, even when migrating for only 4 h/night at speeds of 13–20 km/h. Our calculated values are supported by an observation in the early 1960s of a male Indiana bat that was banded at a cave in Kentucky and recovered 9 days later in southern Michigan, ca. 530 km from the banding site (Davis, 1964; Kurta, 1980). Although this bat apparently was disoriented (it flew from Kentucky to Michigan, an area devoid of caves, in September), this observation does show that Indiana bats are capable of covering these large distances in only a few days.

Relationship of Hibernacula to Summer Roosts

We now have seven bats from the summer colony near Norvell that have been found in hibernation—three from this report and four (A, B, E, and G in Fig. 1) that were described in Kurta and Murray (2002). Although the first four Indiana bats (Kurta and Murray, 2002) were found in four different winters, those in this study were located during the same winter, indicating that the tendency for members of the same maternity colony to hibernate in different caves does not simply represent all bats from a maternity colony collectively changing hibernation sites from year to year. Members of a maternity colony hibernating in different sites apparently is not unique to the colony in Michigan, because four banded Indiana bats from a maternity colony near Knightstown, Indiana, also were found in two different caves during winter (Cope et al., 1978).

The seven Indiana bats from Michigan hibernated in seven different caves that occurred in a 500-km-long, U-shaped arc extending from southwestern Indiana, through southern Kentucky, to northeastern Kentucky (Fig. 1). The geographic distribution of these seven hibernacula mimics the distribution of most known hibernacula of Indiana bats in this area of the Midwest (Gardner and Cook, 2002; A. King, in litt.). There are at least three potential explanations for the pattern shown in Figure 1 that are not mutually exclusive. First, bats from widely separated hibernacula might accidentally have found each other on the summer range and established a summer colony. Second, a maternity colony may have been initially formed by bats from the same hibernaculum, but maternity colonies may be in a constant state of flux, with individuals frequently shifting from one summer colony to another over a period of years while remaining loyal to their overwintering site. Finally, a maternity colony initially may have formed from a group of bats that migrated from the same hibernaculum, but over many years, various individuals changed their hibernation site while remaining loyal to the summer range.

A strategy of accidentally finding potential roostmates after a long migration seems risky and makes the first scenario unlikely. Banding data indicate that Indiana bats are loyal to their summer range, especially adult females and their female offspring (Cope et al., 1978; Gardner et al., 1991; Kurta and Murray, 2002), and the tenacity with which maternity colonies hold on in the face of urban expansion suggests strong fidelity to summer sites (Sparks, 2003). Although these bats also display some fidelity to hibernacula, there are many examples of banded Indiana bats changing caves (Hall, 1962). In addition, the rapid increase in the number of Indiana bats hibernating in some newly abandoned mines (e.g., Kath, 2002) suggests that changing hibernation sites is not uncommon. Thus, the third scenario seems the most reasonable at this time.

Acknowledgments

Funding for the summer study of the Indiana bat was provided by the Michigan Department of Natural Resources. We thank R. Trachet for allowing us to work on his property, and E. Hough for helping net Indiana bats in 2004. The first banded Indiana bat from this study was recovered during hibernation by V. Brack; the second bat, by K. Huie, J. Kiser, J. Omar, and C. Rowe; and the third bat, by T. Hemberger, J. MacGregor, and B. Palmer-Ball. We thank C. Butchkoski and C. Herzog for providing unpublished data concerning migration of Indiana bats in the East.

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Echolocation Calls of the Greater Sac-winged Bat (*Saccopteryx bilineata*) in Different Amounts of Clutter

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Introduction

The amount of information that is available to an echolocating bat about an object in its environment is affected by the wavelengths of sound in the bat's echolocation calls (Simmons and Stein, 1980). Bats using calls with high frequencies (short wavelengths) can detect smaller prey and more detail than those using low frequencies (long wavelengths). Bats often use harmonics to achieve higher frequency components and broader bandwidths in their calls (Simmons and Stein, 1980), although high frequencies are more subject to atmospheric attenuation than low frequencies (Lawrence and Simmons, 1982). The actual frequencies produced by aerial-hawking species can be influenced by many parameters, including body size and the hearing-based defenses of prey (Fenton et al., 1998), as well as social setting (Habersetzer, 1981; Ratcliffe et al., 2004; Ulanovsky et al., 2004) and habitat (Obrist, 1995).

Bats, for example, may adjust their echolocation calls according to the degree of "clutter" that they face. Clutter, such as foliage or branches, in the environment can generate echoes from surfaces other than the target, potentially masking echoes from the prey (Sleep and Brigham, 2003). Schnitzler and Kalko (2001) showed that some echolocating bats altered the design of their echolocation calls when hunting and flying in confined and open situations, and Siemers and Schnitzler (2004) predicted that foraging performance in cluttered environments would be affected by the specific design of echolocation calls.

The greater sac-winged bat (*Saccopteryx bilineata*) is an aerial-feeding emballonurid that uses echolocation to detect its prey (Biscardi et al., 2004; Kalko, 1995b). This low-duty-cycle echolocator is a common and widespread neotropical species that hunts flying insects in open areas and along edges (Kalko, 1995b; Yancey et al., 1998). *S. bilineata* shows geographic variation in its calls (Biscardi et al., 2004), and this bat is somewhat unusual in that individuals alternate frequencies with maximum energy between consecutive calls within a sequence (Kalko, 1995b). A variety of feeding situations and geographic variation in calls makes this small bat (forearm = 47.1–49.2 mm; mass = 8.5–9.3 g—Yancy et al., 1998) well suited for studying the responses of echolocating bats to different conditions of clutter.

The purpose of this study was to determine if *S. bilineata* adjusts the design of its echolocation calls in the presence of clutter, and, if it does, to assess specific changes to the calls. I also examined recordings to ascertain if the incidence of echoes was an indicator of the presence of clutter.

Methods

I analyzed search-phase echolocation calls of *S. bilineata* recorded on 23–24 July 2004 at Tortuguero, Costa Rica (10°34'60N, 83°31'0W), and on 27–31 July 2004 at two sites near Jaco, Costa Rica (9°37'0N, 84°37'60W). In my analysis, I used 10 sequences recorded in open settings and 10 in closed situations. I defined open settings as sites with no objects (vegetation, walls, etc.) within 10 m of flying bats, and cluttered situations as those with objects within 3 m of flying bats. When calls were recorded in either setting, the microphone was ca. 2–8 m from the bats, and the bats were flying about 3–8 m above the ground. Echolocation calls were usually recorded from foraging bats, although some individuals may have been commuting. Calls were recorded using a microphone (Avisoft Ultrasoundgate 116; gain = 75% for both open and closed environments) in conjunction with a laptop computer (Dell Latitude D800, running Avisoft USG). The microphone was mounted on a tripod and pointed 60° from the horizontal in both situations.

For analysis, I opened files of recordings with BatSoundPro (version 3.31a, Pettersson Elektronik AB) and measured duration (DUR) and interpulse interval (IPI) using the oscillogram display, and determined the frequency with most energy (FME) from 1,024-line fast Fourier transforms (FFT). To assess the presence of echoes in recordings, I set the threshold of BatSoundPro at 16, and I identified echoes as smears on spectrograms of calls. I used the FFT display to determine the presence of harmonics that were ≥10 dB above background noise. For all analyses, I used only sequences of search-phase calls in which no calls were saturated, the signal was >10% of background noise, and there was no pulse-echo overlap. I did not separately analyze the low- and high-frequency calls that typically alternate within a sequence of calls produced by *S. bilineata* (Biscardi et al., 2004). For statistical analyses, I used the Statistical Package for the Social Sciences (version 12.0), following procedures described in Biscardi et al. (2004). Means are shown ± 1 *SD*.

Results

A total of 202 calls from 20 sequences produced by *S. bilineata* was analyzed. I used a multivariate analysis (MANOVA) to assess variation in call features and found significant overall differences between individual calls recorded in open versus cluttered situations (Wilk's $\lambda = 0.662$; $F_{3,180} = 30.58$; $P < 0.001$), with significant differences for DUR ($F_{1,182} = 83.46$; $P < 0.001$), FME ($F_{1,182} = 9.46$; $P = 0.003$), and IPI ($F_{1,182} = 18.94$; $P < 0.001$). Average duration of calls produced in the open was 8.5 ± 1.5 msec, and in closed situations, 6.6 ± 1.5 msec. Mean interpulse interval in the open was 73.1 ± 28.4 msec, compared with 56.6 ± 24.4 msec in closed situations. Using discriminant function analysis (DFA), I assessed the accuracy with which calls could be assigned to cluttered versus open settings, based on call features, and in a cross-validated test, 74.9% of calls were correctly associated with the setting in which they were recorded.

A MANOVA also indicated significant intersequence variation when all sequences were considered (Wilk's $\lambda = 0.101$; $F_{57,480} = 9.814$; $P < 0.001$). The different parameters again showed significant variation (DUR: $F_{19,164} = 16.3$; $P < 0.001$; FME: $F_{19,164} = 12.082$, $P < 0.001$, and IPI: $F_{19,164} = 6.39$, $P < 0.001$). A DFA cross-validated classification, however, correctly assigned calls to sequence only 40.4% of the time. Despite significant variation in DUR, FME and IPI among sequences, calls were more accurately classified by setting (open versus closed) than by sequence.

Using a Pearson's χ^2, I compared the incidence of harmonics in calls recorded in open and closed situations (*d.f.* = 1 in each case). The fundamental was not more often present in open versus closed settings (χ^2 = 1.88, P = 0.171), nor was the fourth (χ^2 = 2.82, P = 0.93) or fifth harmonic (χ^2 = 0.001, P = 0.98). Obvious echoes of the original calls were significantly more often present in recordings made in closed versus open settings (χ^2 = 24.27, *d.f.* = 1, P < 0.001).

Discussion

My observations indicated that echoes more often appeared in recordings from areas with clutter and that free flying *S. bilineata* adjusted their echolocation calls according to the degree of clutter around them, changing patterns of time and frequency. My findings support previous suggestions that bats adjust their echolocation calls according to the presence of clutter, both in natural situations (Kalko, 1995a, 1995b; Neuweiler et al., 1987) and in comparisons of bats flying indoors and outdoors (Mukhida et al., 2004).

The effective range of echolocation in air is limited by initial call intensity and by a combination of spreading loss and attenuation (Lawrence and Simmons, 1982), and the interpulse intervals of search-phase calls may suggest the maximum range of operation for echolocation by a particular species (Fenton et al., 1998). For *S. bilineata*, I estimated distance to the nearest large obstacle during my recordings and, from maximum IPI, I determined the maximum range of echolocation. Based on this data, I calculated that *S. bilineata* flying at a velocity of 5 m s^{-1} would have been 500–1,000 ms (112–625 forearm lengths) from contact with the nearest obstacle. These times and distances would have given a bat as agile as *S. bilineata* enough time to react and avoid collisions. Scaling the distances to the average forearm length helps put the situation in perspective for the bats.

My results demonstrate the adjustments *S. bilineata* make to their echolocation calls when flying in cluttered situations. These data support earlier work (e.g., Kalko, 1995a, 1995b; Neuweiler et al., 1987; Schnitzler and Kalko, 2001; Siemers and Schnitzler, 2004; Simmons et al., 1979) proposing a connection between echolocation call design and level of clutter. I also found that the incidence of echoes in recordings may be useful as indicator of the level of clutter experienced by bats.

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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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BOOK REVIEW

Bats of Puerto Rico: An Island Focus and a Caribbean Perspective.
Gannon, M.R., A. Kurta, A. Rodríguez-Durán, and M.R. Willig. 2005. Texas Tech Press, Lubbock, TX, U.S.A. 239 pages. ISBN 13-978-89672-551-5.

Anyone planning to study bats in Puerto Rico has two tasks before setting out for the "Enchanted Isle." Obtain a copy of this great little book and then read it from cover to cover! It is lucidly written, refreshingly devoid of jargon, and filled with information about these curious and fascinating animals. It seems impossible to imagine a team of scientists more qualified than these authors to write this book. Rodríguez-Durán is a native and life-long resident of Puerto Rico and brings an enormous fund of "on the spot" information to this work. Kurta, Gannon, and Willig have each spent significant segments of their careers studying bats at various sites on this island. In fact their names are nearly synonymous with the title of this book. It is not only an extremely useful field guide to the distribution of the bats of Puerto Rico but includes a wealth of information about the biology of each species, where to find them, and how they live.

A casual review of a half-dozen recent college texts in ecology does not yield much detail on Puerto Rican ecosystems and this information may be difficult to assemble from original sources. The section on ecosystems in *Bats of Puerto Rico* gives a very thorough introduction to this important aspect of bat biology. These discussions leave one with a fairly comprehensive picture of each species' habitat. Nevertheless, it is awkward that measurements in the text are given in metric units, but English units appear in the maps that portray patterns of rainfall (inches) and temperature (degrees Fahrenheit).

Clearly the family and species accounts are the heart of the book. These are exceptionally well written. The discussion of taxonomy will likely leave the systematists wanting more. Physiologists will want more "blood and guts" on these incredibly interesting and complex animals but that is better found elsewhere. The echolocation specialists will want more sonograms and the morphologists more illustrations but there are other volumes on those topics. One must keep in mind that this book is basically meant as an introduction to the bats of Puerto Rico and on this mission it succeeds admirably.

The short sections on nomenclature are especially interesting, notably the descriptions of the origins of generic and specific names. One occasionally has the impression that some Latin origins seem so obscure that the original meanings of the words have long since been lost. It was refreshing to discover that *Tadarida* is in this category, if indeed it was ever a Latin word at all. Most amusing to me was that after working on *Noctilio leporinus* for many years, it would have been more fun to simply call it the "doglike harelike animal of the night"! It was enlightening to finally learn the origins of the specific epithet "*sezekorni*."

It is difficult in some cases to find a specific locality using the distribution maps provided under each species. Including just one map of similar scale showing the locations of a few of the more prominent physical features such as mountain peaks, rivers, major cities, or major highways, along with the political boundaries shown on the species' maps would help the reader or future field worker to locate some of these places. A good local highway map is of great assistance, but may not be readily available to someone not on the island.

Appendix (8) does give great detail, but to those unfamiliar with the island's geography, finding some of these locations may be a bit daunting.

The keys for identification are straightforward and easy to use. Many keys for identifying small mammals often require the examination of anatomical features too small to be of much use in the field, especially at night under less that ideal conditions, and especially when handling live and agitated bats. These keys do not have that limitation. Admittedly they would hardly suffice for identifying subspecies, but no claims are made that they are meant for this detailed and often difficult work. The keys for skull identification are very user friendly. The tables of body measurements (Appendix 2) and cranial dimensions (3) are valuable and well documented. The list of technical names of native plants (6) and the list of parasites (4) are most useful.

The Glossary includes many useful terms, some of which may be new to the general reader, but the selection of terms seems spotty. There are definitions of the dietary types: fungivore, detritivore, omnivore, and insectivore, but the terms piscivore, frugivore, and sanguivore are not included even though these are important dietary terms concerning fishing bats, fruit bats, and vampires all discussed in the text (even though there are no vampires on the island).

A bibliography containing nearly 300 references is extremely valuable to anyone interested in working on the bats of Puerto Rico or any other Neotropical islands. This list of references will be a good starting point for anyone working on bats in the Caribbean region and will answer many questions about the distribution of these species. The U.S. Virgin Islands are located within sight distance of Puerto Rico and share several of these species. In fact no species occur on the Virgin Islands that do not also appear in Puerto Rico. A few comments about these very close neighbors might have made this book even more complete. In all, this is a very useful little book and a must for naturalists, mammalogists, and bat-workers everywhere.

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

ANNOUNCEMENT and CALL FOR PAPERS

Vladimír Hanák Volume

Dear colleagues,

This year Vladimír Hanák, a prominent Czech zoologist, will celebrate his 75th birthday. Vladimír is professor emeritus in vertebrate zoology at the Charles University in Prague, a founder of the modern "Prague Mammalogical School," and our teacher. This special occasion is worth remembering not only in recognition of Vladimír's many contributions to the knowledge of the Palaearctic fauna of bats and other mammals, but also—as perhaps everyone who knows him personally will agree—in recognition of Vladimír himself. Therefore, in honor of Vladimír's 75th birthday, we would like to compile a volume of papers, and we invite you and/or your colleagues to contribute to this volume.

The papers will be published as a special volume of the Czech mammalogical journal *Lynx* issued by the National Museum in Prague by the end of the year. The topic of individual contributions is not specifically delimited other than the focus of the journal (i.e., mammals). However, papers concerning the zoology of bats (taxonomy, fauna, zoogeography, biology) are most welcome. The deadline for presenting manuscripts (in English, and preferably in an electronic form by e-mail) is the end of May 2006. Manuscript length is not restricted, but manuscripts exceeding 30 pages should be announced in advance please. Please let us know as soon as possible if you (and/or your colleagues) are planning to contribute to the volume, and if so. the title of your contribution and how many text pages and plates should be reserved for it. Further details will be communicated later.

We thank you in advance, and we look forward to any comments from you regarding this celebration and special volume.

With cordial greetings,

Ivan Horáček, Prof. Dr., Ph.D.

Department of Zoology
Charles University
Viničná 7
CZ–128 44 Praha 2
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Petr Benda, Dr., Ph.D.

Department of Zoology
National Museum
Václavské nám. 68
CZ–115 79 Praha 1
Czech Republic

Preferable contact: **petr.benda@nm.cz**

ANNOUNCEMENTS

Titley Electronics Pty. Ltd.

David and Lyn Titley, having recently sold the business of Titley Electronics Pty Ltd., would like to extend to everyone our very best (belated) wishes for the Christmas season, and the year ahead.

We have thoroughly enjoyed our involvement in the world of ecology, conservation and science. We're going to miss the contact we've had with so many wonderful people, both locally and throughout the world, during our 27 years with Titley Electronics. We appreciate and thank you for your friendship and business and hope that you will give your continuing support to the new owners of Titley Electronics, who will maintain the original company name and contact details (**http://www.titley.com.au**).

With sincere best wishes,
David and Lyn Titley

Volunteers Needed to Assist with Research in Southern Utah

Six volunteers are needed from July 10–21, 2006, to assist in radio-tracking Townsend's big-eared bats. Radio telemetry experience is preferred, but not absolutely necessary. Work will be based out of Kanab, UT.

Additional volunteers, for both mist netting and as helpers, are needed to assist in bat inventory (mist netting and acoustic sampling) on the Grand Staircase-Escalante National Monument. Mist netting volunteers must have experience working with bats, and be current on rabies vaccinations. Helpers will not be able to handle bats, but will assist in mist netting operations. Work will be in remote locations, and will entail camping for several days at a time. The project will occur from approx. June 12–July 7, 2006, and a minimum commitment of one week is required. Contact Melissa Siders (**msiders@blm.gov**) if you have questions.

Send resume and references to:
Melissa Siders
Grand Staircase-Escalante National Monument
190 E. Center Street
Kanab, UT 84741

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.

Requirements (please send these documents to the address below):

- A short description of your work, no more than four pages long in Spanish. Include: Title, author(s), abstract, introduction, methodology, results and discussion (please include tables and figures).
- Applicants must be currently enrolled graduate or undergraduate students at a Mexican University, or must have graduated during the past year (i.e., since the end of the most recent NASBR meeting) from a Mexican University. Please send official copy of documentation authorizing student standing or date of graduation.
- Two letters of recommendation (one from the Advisor)

Number of grants per year:	One
Deadline for delivery of documents:	April 28th, 2006
Publication/notification of results:	June 5th, 2006

Please send the above requested documents to:

Arnulfo Moreno
Instituto Tecnológico de Cd. Victoria
Boulevard Emilio Portes Gil 1301 Pte.
Cd. Victoria, Tamaulipas
C.P. 87010
México
Tel. (834) 3130662, ext 257; Fax. (834) 3133646
e-mail: **leptonycteris2000@yahoo.com.mx**

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.

El premio incluye transporte, hospedaje y costo del registro al Simposio.

Requisitos (enviar estos documentos a la dirección abajo mencionada):

- 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.
- Ser estudiante de Licenciatura o Postgrado, inscrito o con un año o menos de haber egresado de una institución mexicana (copia de credencial de estudiante vigente o similar).
- Dos cartas de recomendación (una de su director de tesis).

Número de Becas que otorga por año: una

Premio Bernardo Villa a la investigación en Murciélagos (cont.)

Fecha limite para entrega de documentos: 28 de Abril de 2006

Publicación de resultados: 5 de Junio de 2006

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México
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e-mail: leptonycteris2000@yahoo.com.mx

Please share the above information (in English or Spanish) with all interested individuals. Thank you!

FUTURE MEETINGS and EVENTS

April 19–21, 2006
The 12th Australasian Bat Society Conference will be held at the University of Auckland, New Zealand, on 19–21 April 2006, with a welcoming function on Tuesday evening, 18 April. For information about the conference, please contact Stuart Parsons: **s.parsons@auckland.ac.nz**

October 18–21, 2006
The 36th Annual NASBR will be held in Wilmington, North Carolina, 18–21 October 2006. Information will be posted on the NASBR web site when available (**http//www.nasbr.org/**).

BAT RESEARCH NEWS

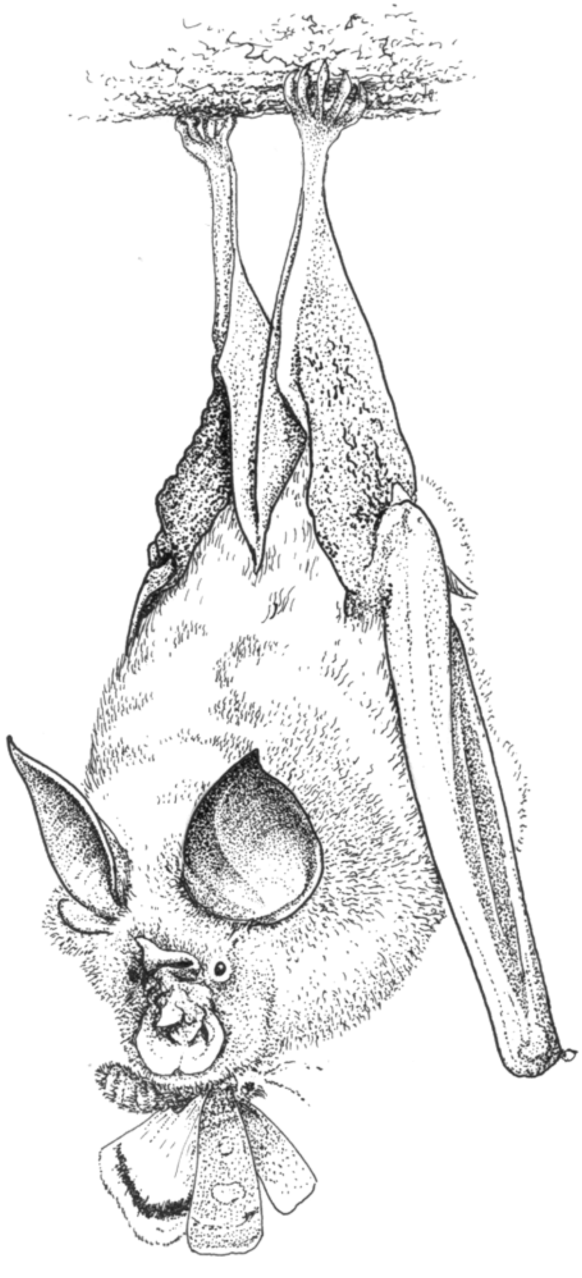
VOLUME 47: No. 1 **Spring 2006**

Table of Contents

Front Cover

The illustration on the front cover is a ventral view of the deepest hyoid structures and of the larynx of the New Zealand bat, *Mystacina tuberculata*, and was drawn by Thomas A. Griffiths, Illinois Wesleyan University, Bloomington, IL. (Copyright 2006 by the artist. All rights reserved.)

BAT RESEARCH NEWS



VOLUME 47: No. 2 Summer 2006

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Bat Research News is published four times each year, consisting of one volume of four issues. *Bat Research News* publishes short feature articles and general interest notes that are reviewed by at least two scholars in that field. In addition, *Bat Research News* includes a recent literature section that cites nearly all bat-related publications in English worldwide; the abstracts of presentations at bat conferences around the world; letters to the Editors; news submitted by our readers, notices and requests, and announcements of future bat conferences worldwide.

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

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Migrating Bats Interacting with Wind Turbines: What Birds Can Tell Us

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Introduction

Providing renewable energy from the wind is a fast-growing industry in the United States since government subsidies have reduced the economic advantage of fossil fuels (Rohrman, 2005). Modern wind turbines are ca. 120-m tall, with blade tips traveling at ca. 70 m/sec, and these structures have long been implicated in the death of migrant birds. A few years ago, workers searching beneath turbines for birds in the East discovered that carcasses of migratory bats actually were more common than dead birds (National Wind Coordinating Committee, 2004). However, research on the interaction of bats and wind turbines has been limited. To deal with this conservation issue, biologists ultimately need to relate numbers of bats killed to population sizes, to discover what migratory behaviors put certain species at risk, and eventually to develop means to reduce or prevent bat casualties at wind turbines.

Most North American fatalities (83% in early studies) involve tree-roosting bats in the genera *Lasiurus* and *Lasionycteris* that are often killed during apparent migration in August and early September (Johnson, 2005). At recent national meetings, biologists, who lack fundamental information about migrating bats, have used small, night-migrating birds as surrogates for bats when formulating hypotheses and suggesting research techniques, but the appropriateness of this surrogacy is unknown. The purpose of this paper is not to provide a comprehensive review of chiropteran or avian mortality at wind turbines or associated research methods (Gauthreaux, 1996a, 1996b; Johnson, 2005) but to provide bat biologists with information on aspects of bird migration that might be useful in designing research on bat migration.

Terminology

Researchers studying flying animals often use biased terminology. For instance, most migration over land by small birds (largely passerines) takes place at night, and observations necessarily involve poorly defined distant forms or abstract images on a radar unit. Overenthusiastic observers, particularly "radar ornithologists" (including this one), often refer to "migrating birds" or "land birds" when "flying vertebrates" is more correct. In this review, "flying vertebrates" or "migrants" will designate animals that often are presumed to be birds by ornithologists but are probably both birds and mammals, whereas the terms "bats" and "birds" will be used when the class of vertebrates is not open to serious question.

Techniques for Studying Migratory Behavior

Most techniques that are used to study migration of vertebrates are indirect and have limitations that influence our understanding of migratory behavior. Such techniques include searches for killed animals beneath tall structures, analyses of DNA and other chemical clues, observations

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at night with optical instruments and radar, and banding.

Carcasses retrieved beneath tall structures provide a perspective on flying vertebrates that has been exploited both to learn about migration and to attempt to reduce mortality (Avery et al., 1980). Collisions of migrant birds at tall towers are far more common in fall than spring (Crawford and Engstrom, 2001), although long-term studies indicate decreases in the number of dead birds over multi-year spans for reasons that are unclear (Clark et al., 2005). Some migrating birds react to lights on tall towers (Larkin and Frase, 1988), as well as illuminated buildings, lighthouses, fires on hilltops, and lighted oil rigs, especially on nights with clouds at low height. For this reason, the number of dead birds beneath a structure is a function not only of the number of low-flying migrating birds but also of weather and visibility. No obvious increase in number of dead bats is noted on such nights, indicating that bats behave differently (but see Van Gelder, 1956). Limited evidence suggests that bats may be killed or injured by accidentally striking guy wires of towers or other obstacles when flying straight, rather than reacting to the structure or its lights (Crawford and Baker, 1981). Therefore, unlike the situation with birds, the numbers of bat carcasses beneath towers or tall buildings may be correlated with the passage rate of migrating bats or activity of feeding bats at or below the height of the structure. Although some wind turbines have lights meant to warn aircraft, there is no evidence that the lights pose a hazard to bats (Johnson, 2005).

Knowledge of where migrants spend the summer and winter may be useful in understanding differences in mortality among species, seasons, and geographic regions. Genetic and chemical markers can be used to indicate the source population for a bird or bat and where it was feeding when it produced certain tissues (Cryan et al., 2004; Fleming and Eby, 2003; Hobson, 2005). Trace minerals in feathers can be used to distinguish source populations of certain kinds of geese (Hanson and Jones, 1976), and use of DNA and two stable isotopes together provides over 75% accuracy in assigning wintering song birds in South and Central America to breeding regions in the western United States and Canada (Kelly et al., 2005). Such methods provide insight on migration, especially when used on animals sampled en route, such as at wind turbines, but their use is not without pitfalls. For instance, claims about the end points of migration must be based on captured animals that are known to be breeding or wintering and not engaged in misleading behavior, such as the molt migration of some birds.

Thermal (passive infrared) imaging can detect flying vertebrates around wind turbines (Arnett et al., 2005; Winkelman, 1985) and out to about 3 km (Liechti et al., 1995), but unless one uses at least two such devices to triangulate the distance to the flying animal, its height is in doubt. Radar can locate flying animals in three dimensions but cannot presently discriminate North American bats from similar-size birds (Cooper, 1996: B. Cooper, pers. comm.; R. P. Larkin, pers. obs.; T. Williams, pers. comm.; but see Bruderer and Popa-Lisseanu, 2005). With future advances in radar technology, biologists might be able to detect a different radar echo fluctuation from the vascularized wings of bats compared with the echo from the feather-covered wings of birds.

Capturing migrant birds during stopover and attaching bands has yielded important information on the overall routes and seasonal timing of migration by different ages, sexes, and species. Marking bats has been much more limited than in birds but nevertheless informative (Griffin, 1970). High mist nets, such as those used to capture migrating birds (Bolshakov et al., 2000), could be used to catch bats even around turbine blades at night. Such ground-based fieldwork does not, however, give a good picture of the temporal process of migration, such as day-by-day timing of migratory events or their correlation with weather or other environmental conditions. Numerous authors report poor correlations between numbers of migrating birds captured on the ground in the daytime and estimates of nocturnal migration rates from radar (Alerstam, 1972; Parslow, 1962; Williams et al., 1981; Zehndner and Karlsson, 2001), and perhaps this discrepancy may be partly due to the inclusion of migrating bats in estimates from radar.

Migratory Bats

As we learn more about bat migration, we probably will find considerable individual, species-specific, and temporal variability. To date, two kinds of migration have been identified in north temperate bats. First, migration can involve seasonal (spring/fall) flights between warm-weather breeding areas and more southern sites, often hundreds of kilometers away. At wintering locations, food (flying insects) is either occasionally available on warm nights, or if the site is far enough south, food may be available throughout winter. This definition of migration corresponds to the restricted one usually employed by ornithologists (Berthold, 2001; Dingle, 1996). Second, migration in bats can also refer to long or short seasonal movements to and from hibernacula, such as caves or mines, which need not be at a warmer altitude or latitude.

In contrast, various kinds of migration have been identified in birds. For instance, "partial migration" refers to the common case in which not all individuals or populations of a species migrate, and "facultative movement" refers to irruptions or other potentially long-distance movements that may be weather-related or irregular in occurrence (Wingfield, 2003). In addition, certain species of birds are prone to disperse or "wander" hundreds of kilometers in late summer or early fall before flying south in earnest (e.g., Erwin et al., 1996; Raveling, 1976). Whether bats make similar types of movements remains unknown.

Palearctic bats have been categorized according to whether and how they migrate (Fleming and Eby, 2003), but no similar classification seems to exist for Nearctic bats. Although Fleming and Eby (2003) review the physiology and energetics of bat migration, the actual process of migration in bats is poorly understood in contrast to birds. Reducing bat mortality at wind turbines requires answers to fundamental questions such as which species migrate; how many bats migrate; when, where, and how high do they fly; and the nature of bats' adaptations for meeting the behavioral challenges of long-distance flight.

The Process of Bird Migration as It Pertains to Bats

Where migrating bats fly matters both at a continental scale, to understand why wind-energy facilities in different regions may pose different degrees of danger (Johnson, 2005), and at a local scale, to aid in siting decisions for wind-energy facilities. Popular accounts of migration almost always deal with routes, corridors, and flyways, concepts that probably originated with hunting of birds that depend on waterways during migratory stopover. Although Fleming and Eby (2003) present data on use of large-scale migratory corridors by nectivorous bats, actual migratory routes taken by North

American tree bats are unknown, except for spotty band recoveries.

Based on the ornithological data, we do not expect bats to fly in narrow corridors over level terrain or large bodies of water. Studies of night-migrating thrushes (Turdidae) that carried radio transmitters (Cochran and Kjos, 1985; Diehl and Larkin, 1998) failed to show specific migratory paths over the earth. Similarly, studies with radar show that huge numbers of mixed species of nocturnal migrants (probably mostly birds) blanket the earth evenly once they are aloft and cruising, with no evidence of corridors or flyways (Fig. 1; Diehl et al., 2003; Gauthreaux and Belser, 2003; Gauthreaux et al., 2002; Graber, 1968). That generalization usually holds over level terrain, low hills, and, to some extent, even large bodies of water, but some nocturnal migrants encountering mountains alter their course to fly along valleys and ridges (Bruderer and Jenni, 1990), where winds and topography interact (Bruderer, 1978).

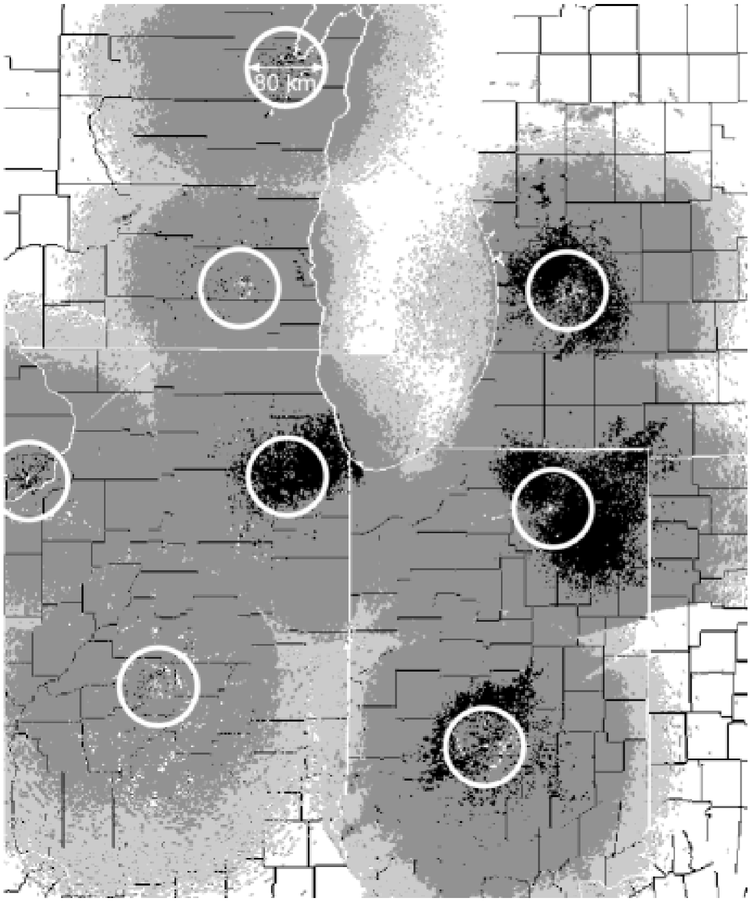

Figure 1. Flying animals blanketing parts of Illinois, Indiana, Michigan, and Wisconsin, during nocturnal migration. The southern part of Lake Michigan is in the top center of the figure. No corridors or flyways are visible on this typical night of migration. Circles have a radius of 40 km and are centered on National Weather Service WSR-88D (Nexrad) Doppler radars. Darker areas are more intense radar echoes. Irregularities in the black patterns are largely ground clutter and obstruction and reflection of the beams by topographic features and buildings near the radar units. The image is a grayscale composite of color images courtesy of weathertap.com, taken on 1 October 1998, at 2132–2139 hours Central Standard Time, with the radar at an elevation of 0.5˚.

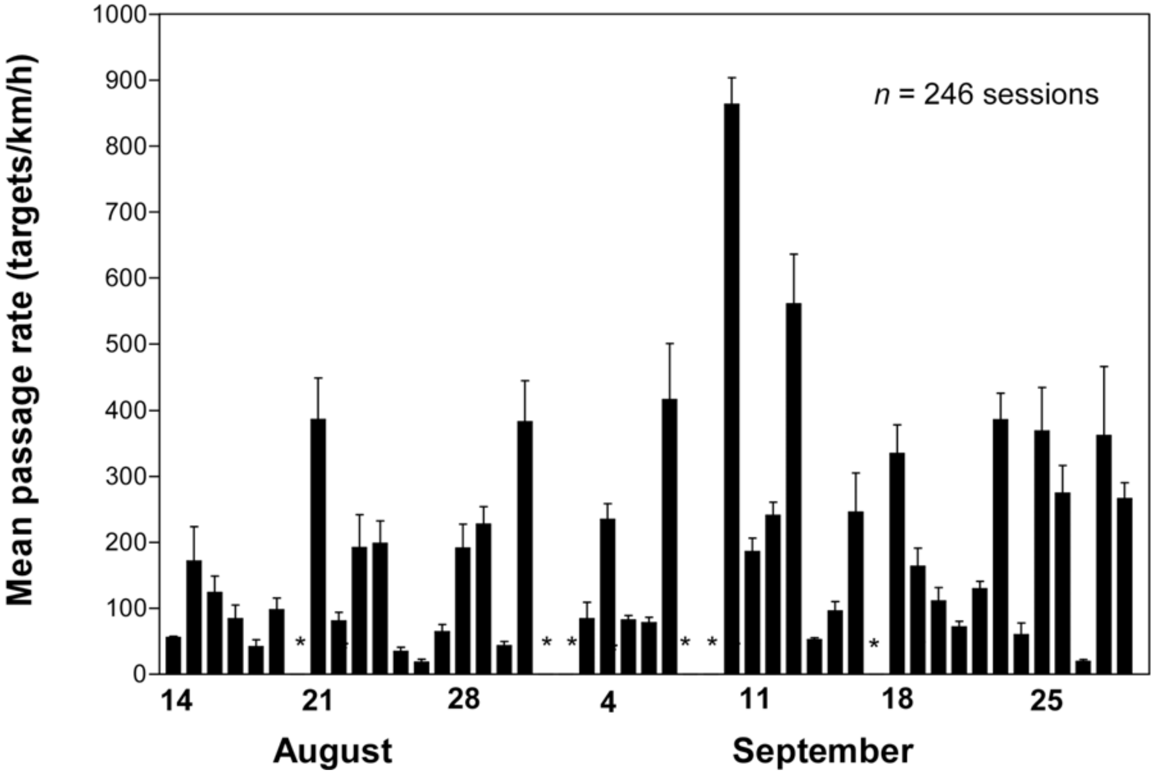

Figure 2. Night-to-night variability in passage rates of nocturnal migrants (see also Mabee et al., in press). A small, short-range, X-band radar operated every night during most of a fall migration season in the northeastern United States. Numbers of flying animals vary by about two orders of magnitude from night to night. An asterisk above the *x*-axis indicates a lack of data, usually caused by steady rain, although little migration is expected under such conditions. Data courtesy of T. Mabee and B. Cooper, ABR, Inc.

Windy heights are of special importance to the wind-energy industry, and flying vertebrates encountering ridges and mountains have been studied in Europe and Israel (Bruderer and Jenni, 1988, 1990; Bruderer and Liechti, 1995), as well as North America (Cooper et al., 2004; Mabee and Cooper, 2004; Seilman et al., 1981; Williams et al., 2001).

Intrinsically high temporal variability means that conclusions about migratory events, including mortality at wind turbines, should not be based on short-duration field projects. The number of migrants aloft or the number per unit time passing over a line or circle on the ground (the passage rate) varies enormously from night to night (Fig. 2). This high variability is related to long-term seasonal changes (mainly day length—Berthold, 1996) and an intercorrelated set of weather variables, the most important of which are direction and speed of the wind (Dingle, 1996; Liechti and Bruderer, 1998; Richardson, 1978, 1991). Because air speed (speed of flight relative to the air) of small birds and the wind speed are often comparable, the wind has a large effect on the effort required to progress in a given direction. Winds aligned with the direction of flight by migrants (“following winds”) often precede a large migratory wave, although different species at a single location may prefer to fly in winds from different directions (Crawford, 1980; Richardson, 1978). Some birds can even deduce the wind vector while aloft during nocturnal flight (Berthold, 2001).

The height of bats engaged in long-distance migratory flight is critical to understanding their risk at wind turbines. Although daily feeding flights of Brazilian free-tailed bats, *Tadarida brasiliensis*, can exceed 3 km above the ground (Williams et al., 1973), the height of migratory flights by *T. brasiliensis* or any other North American bat is unknown. Small birds migrate at night within ca. 1–1.5 km above nonmountainous terrain, although technical problems have often prevented researchers from gaining accurate counts of nocturnal migrants flying at very low altitudes (Gauthreaux, 1996b; Larkin, 2005; Nisbet and Drury, 1968). In one study, direct observation of migrating animals from a small aircraft at night found more low-flying migrants than most other techniques (Bellrose, 1971), but this work has never been replicated. Some low-flying migrants may fly so low that they pass beneath the rotor-swept area of a turbine, but because low-flying migrants often ascend only to the minimum height needed to clear topographic obstacles, we may expect more migrants to encounter wind turbines on high ground (Bruderer, 1994; T. Williams, pers. comm.).

Migrating bats fly in winds that often show vertical structure in the planetary boundary layer (PBL), i.e., that part of the atmosphere closest to the earth (Angevine et al., 1998; Kaimal and Finnighan, 1994; Liechti and Schaller, 1999). Migrants may select narrowly defined height bands with favorable winds in such structured conditions. Over flat terrain, the height of the PBL on a clear night is initially only a few meters above the ground but commonly rises to 1 km or more during the evening. In this situation, turbine blades will cut the air progressively above, at, and below the PBL. We do not know how the nocturnal course of the PBL, migrating animals, terrain, and wind turbines interact.

Some biologists speculate that wind turbines kill bats that are feeding on insects and spiders that are somehow attracted to or concentrated by rotating turbine blades (Arnett et al., 2005). Insectivorous birds, however, do not feed on the wing during nocturnal migration; instead, they forage intensively in daylight after descending to the ground or trees, during a phase of migration known as stopover (Hutto, 1998). Although migrating bats are not reported to feed during the daytime on migratory stopover, there is no reason to believe that they do or do not have a similar overall approach to refueling during migration. Insects can cluster in narrow height bands in the PBL (Beerwinkle et al., 1994), and if bats feed in the course of migratory flight, they may change height opportunistically to find concentrations of arthropods, like some molossids do during nightly foraging (Griffin and Thompson, 1982; Menzel et al., 2000). Alternatively, bats may use some combination of feeding while migrating and during stopover. Stomach contents of fresh carcasses beneath wind turbines may provide information about this issue.

Wind turbines may cause fatalities by somehow disorienting bats; if so, the mechanism of disruption may be neither simple nor obvious. Early attempts to understand the remarkable orientation and navigation abilities of birds attempted to use parsimony and discover one subtle, pervasive cue and its related sensory modality to explain how birds find an exact spot on the earth from hundreds or thousands of kilometers away. Many studies with birds have since shown that simple ideas cannot explain long-distance navigation and homing, and current thought on avian navigation is based on the idea of a hierarchy of partly redundant celestial, landmark, acoustic, magnetic, and probably other cues (Berthold, 2001; Mouritsen, 2003; Wiltschko and Wiltschko, 1999). For instance, when magnetic cues contradict celestial cues, birds may recalibrate their celestial orientation based on the perceived magnetic field (Cochran et al., 2004; Wiltschko et al., 1999). Bats are unusual among mammals in possessing an organ of Vitali (Paige, 1995), and perhaps it plays a role in orientation or navigation. Furthermore, the effects of electromagnetic energy should not be discounted (Beason et al., 1997; Larkin and Sutherland, 1977).

Flocking appears to occur in some migrating North American bats (Griffin, 1970) and at considerable height in *T. brasiliensis* (Williams et al., 1973). Flocking by small migrating birds at night is still poorly understood. It probably holds no lessons for students of bat migration, except that the tight, well-organized flocks of small birds that one sees in daytime are not common in nocturnal migration (Larkin, 1982; Moore, 1990).

Coastal waters, which are often shallow, unoccupied and windy, represent an attractive place to put wind turbines, but bats do fly over large bodies of water, including portions of the Atlantic Ocean (Griffin, 1940, 1970; Mackiewicz and Backus, 1956; Peterson, 1970; Reynolds et al., 1997) and the Great Lakes (Griffin, 1940; Nichols and Stones, 1971). As on land, height of movement by bats over water is important with respect to wind turbines. Although small birds often fly low over open water at night and ascend at dawn to look for land (Diehl et al., 2003; Lee, 1963), quantification of the height distribution of birds engaged in overwater movement is yet to be accomplished in North America, except for birds arriving on the Gulf Coast of the United States (Gauthreaux, 1972). That a 20-g bird may undertake a 2,300-km flight, apparently without the possibility of food, water, or rest, indicates that the alternative, terrestrial migration routes must exert powerful negative selection pressures (Larkin et al., 1979; Ibánez et al., 2001; Sillett and Holmes, 2002; Walter, 1979). In the last century, human-made structures have become an important addition to those selection pressures.

Final Comments

The current advocacy of “green energy” means that problems posed by wind-power installations for wildlife will quickly spread. Our limited knowledge of the migratory behavior of bats seriously limits our ability to understand why these mammals are being killed by such installations and, therefore, our ability to correct the situation. Quick solutions, such as discovering a deterrent to keep bats away from turbines, are premature until more is known about the biology of bat migration. Biologists have studied avian migration for many years (Gauthreaux, 1996a), and much of what is known may be useful in understanding the process of migration in bats.

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A Technique for Surveying Bats in Narrow Habitat Corridors

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Introduction

A project entitled "Bats and the Millennium Link" was launched in 2000 to study bat populations along a network of canals (the Forth & Clyde and Union canals) that connect the east and west coasts of Scotland. To assist with these studies, we developed a Recordable Remote Heterodyne Detector System (RRHDS). This robust system is ideal for studying bats that typically commute and/or forage close to narrow waterways, such as Daubenton's bat, *Myotis daubentonii* (Vaughan et al., 1997). Our system has been used in Scotland on 117 occasions, between 2001 and 2005, and is capable of providing information concerning the direction toward a bat roost and minimum number of bats present, as well as information concerning foraging and other activities.

Design and Use of the System

In our system, four heterodyne bat detectors (Bat Box III, Batbox Ltd., Steyning, United Kingdom) are each tuned to a frequency that is appropriate for the target species and then mounted on individual tripods. One end of a 100-m-long, digital audio cable is connected to the headphone socket of each detector, thus disabling each speaker, and the other end is connected to one channel of a four-track tape recorder, with input volume for the recorder set to 80% to minimize distortion. With 100 m of cable, detectors potentially can be stationed 100 m from the recorder, resulting in a transect that is up to 200 m in length (Fig. 1).

The recorder that we use has an output socket for headphones, which allows us to hear the sounds as they are recorded, and a separate LED (light-emitting diode) display for each channel, which tells us when a particular channel is being activated (Fig. 2). Therefore, as a bat travels past a detector and echolocation sounds are recorded on the corresponding channel, we simultaneously hear the sounds in the headphones as the appropriate LED comes on. This provides both an audio and visual reference and allows an on-site observer to track the movement of individual bats as they pass along the transect. Activity audible to the detectors, of course, is also recorded on tape, which allows various analyses to be conducted in the comfort of the laboratory. We modified our recorder so that it could be powered by a lead-acid battery (7 amp/h; 12 v) that provided power for more than 4 h.

Discussion

The RRHDS can provide information on many aspects of bat activity. For example, use of the system can provide clues as to the location of a bat's roost, because one can easily determine the direction of a bat's flight in a narrow corridor with the RRHDS. If the bat is recorded soon after evening emergence, then the bat likely is flying away

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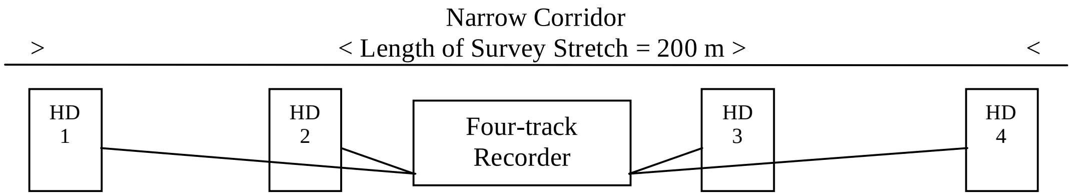

Figure 1. Placement of detectors and recorder of the Recordable Remote Heterodyne Detector System (RRHDS) along a narrow corridor.

from its roost (Limpens, 1993). Such directional information has allowed us to estimate how many different roosts and populations of bats exist along the total length of the canal system and has helped us to find two important roosts.

The system also helps establish the minimum number of bats present as they commute along a narrow transect. For example, if a bat flies past from east to west and is quickly followed by two other bats going in the same direction, then it is likely that a total of three bats have passed. If the first animal is immediately followed by five other bats traveling in the same direction, then it is likely that six bats have passed and so on. Furthermore, speed of travel, number of bat passes, and number of feeding buzzes can be determined with this system, and data collected from several surveys at each site have allowed us to build a good picture of how bats are using their habitat.

Our system has a number of advantages over typical hand-held detector surveys. The use of tripods means that multiple surveyors are not necessary, and because numerous individuals are not required to hold bat detectors in place for long periods, variation in detector orientation throughout the night is eliminated. Recording the sounds also means that there is less risk of data being missed or misinterpreted due to differing levels of experience among surveyors. In addition, the chronological sequence of events along the transect is immediately apparent to an on-site observer and easily verified from the recordings, and the time required to dovetail and interpret results collected by separate observers is eliminated.

As with all techniques, the RRHDS has limitations. Minimum number of bats becomes difficult to assess when many bats travel along the corridor in opposite directions. If there are many bats present at any one time, it can be difficult to establish the direction of flight for individuals and thus determine direction to a roost, although the presence of multiple bats becomes less important as the evening progresses, because it is data from the first few bats that give the strongest indication of roost direction. The RRHDS works well with *M. daubentonii* along canals, but if other species or habitats are studied, bats could fly behind the detectors and not set them off; consequently, reliable use of the RRHDS requires that the user has some preliminary knowledge of the behavior of the study species. Nevertheless, even when these problems exist, bat passes and feeding activity can still be monitored and recorded, and comparisons made with other sites or dates.

Use of the RRHDS is not restricted to canals. We have used the equipment for monitoring bat activity at adjacent mine shafts and for assessing use of bridges, which were slated for maintenance. Other potential sites where this system might be used include river corridors, steep valleys,

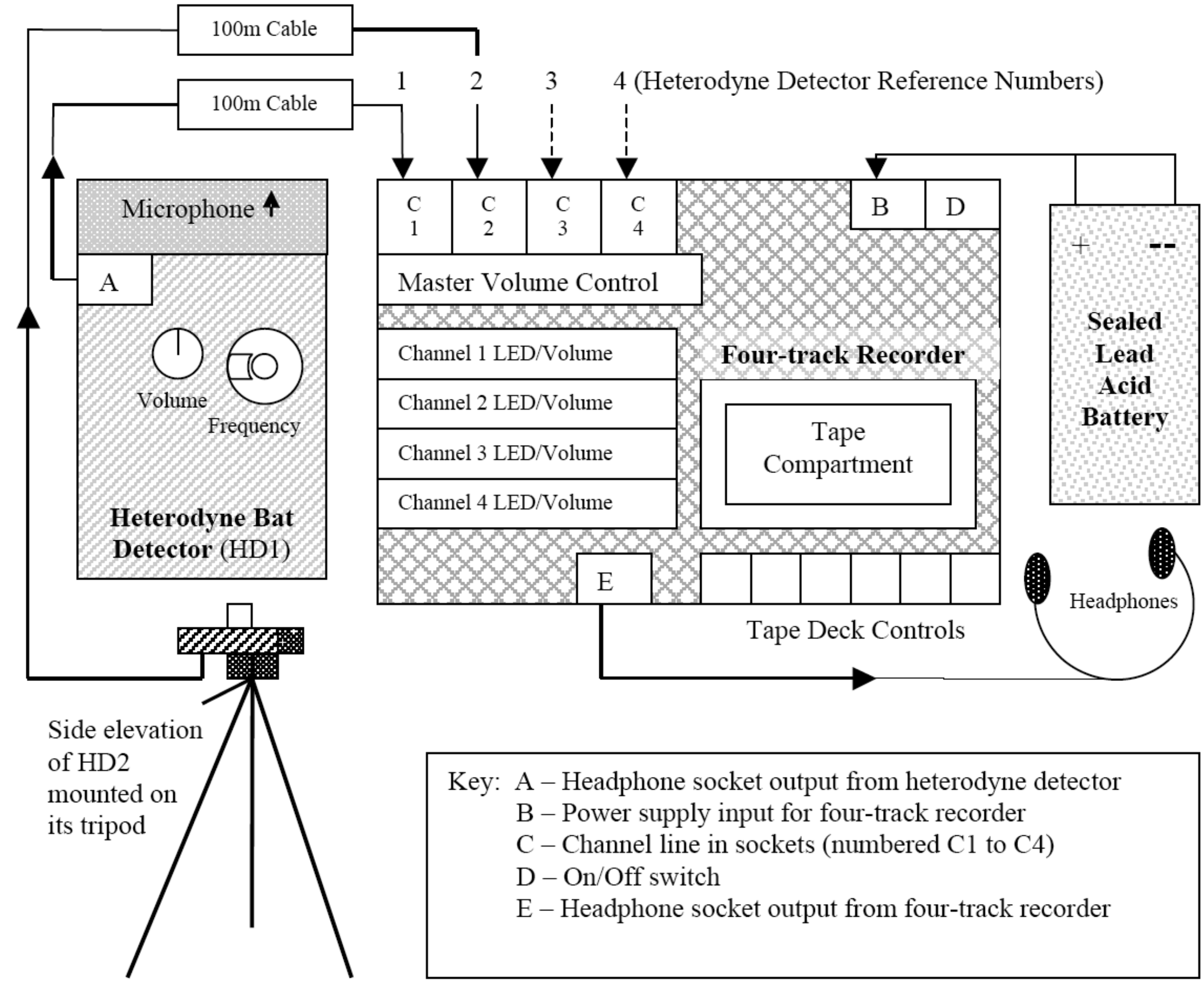

Figure 2. Diagrammatic view of the components of the Recordable Remote Heterodyne Detector System (RRHDS). Items are not to scale.

and different positions within or surrounding large buildings. The authors welcome any correspondence concerning the details of the RRHDS and its application to other situations.

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An Accidental Record of the Northern Yellow Bat, *Lasiurus intermedius*, in Illinois

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The northern yellow bat, *Lasiurus intermedius* is a solitary, apparently nonmigratory species that roosts mainly in dead palm fronds and clumps of Spanish moss, *Tillandsia usneoides* (Webster, 1999; Webster et al., 1980). This species inhabits mostly tropical regions, occurring from Costa Rica in Central America north to South Carolina in the southeastern United States (Rodríguez-H. et al., 2003; Webster et al., 1980). In this paper, I report a new geographic record for *L. intermedius*, from a locality that is at least 900 km farther north than its normal distribution.

While examining specimens in the collection of the Field Museum of Natural History, I noticed an adult female bat (FMNH 167010), preserved as a skin, skull, and skeleton, which was collected in La Grange, Cook County, Illinois, on 26 January 1995. Information from the specimen tag and the catalog of the preparation laboratory indicated that this bat apparently was found dead, hanging from a flower basket in the back room of a florist's shop. This specimen is a medium-sized lasiurine, with yellowish fur, and is labeled as *L. intermedius*. The appearance of *L. intermedius* is superficially most like that of the southern yellow bat, *L. ega*, both of which are in the subgenus *Dasypterus*. However, measurements (mm) of the specimen from the museum tag are total length, 120; length of tail, 42; height of ear, 16; and length of forearm, 55. Some cranial measurements that I made are condylocanine length, 18.4; length of maxillary toothrow, 6.8; and zygomatic breadth, 13.6. These measurements exceed the upper values of the range expected for *L. ega* (Kurta and Lehr, 1995; Webster et al., 1980) and indicate that the specimen from Illinois is correctly identified as *L. intermedius*.

The presence of this tropical tree-roosting species in a building in Illinois during winter, as well as the large distance from the normal range of the species, suggests that this specimen of *L. intermedius* represents an example of accidental transport. The flower shop where the specimen was found at one time received shipments of Spanish moss from Florida, and it is possible that this bat was transported in one of those shipments. Extralimital records of bats are uncommon (Long, 2003), but there are at least two other such reports for *L. intermedius*, one from South Carolina (Rageot, 1955) and one from New Jersey (Koopman, 1965), although it is not known how those bats arrived at their final destination. Other records of bats that were probably transported by human means are described in Irwin and Baker (1967) and Jarrín-V. (2003). When one considers the large amount of cargo shipped to urban zones such as Chicago, it is surprising that more cases of accidental transport are not known.

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FUTURE MEETINGS and EVENTS

August 5th, 2006
The 5th Annual Great Lakes Bat Festival will be held from 10 a.m.–10 p.m. at the Cranbrook Institute of Science in Bloomfield Hills, MI. The festival is organized by the Organization for Bat Conservation at Cranbrook Institute of Science. For more information about this event, please see the OBC website (http://www.batconservation.org).

September 22–24, 2006
The National Bat Conference, organized by the Bat Conservation Trust, will be held in Reading, UK. Please check the following URL for information about the conference (http://www.eurobats.org/news_events/bat_events.htm).

October 18–21, 2006
The 36th Annual North American Symposium on Bat Research (NASBR) will be held in Wilmington, North Carolina, 18–21 October 2006. Please check the NASBR website (http://www.nasbr.org/) for information about the meeting and pre-conference trip.

August 19–23, 2007
The 37th Annual NASBR will be held in Merida, Yucatan, Mexico, 19–23 August 2007. For more information, please check the NASBR website (http://www.nasbr.org/).

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

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

BAT RESEARCH NEWS

VOLUME 47: No. 2 **Summer 2006**

Table of Contents

Front Cover

The drawing of *Rhinolophus ferrumequinum* on the front cover was provided by Tom McOwat of Llandysul, Wales. (Copyright 2006 by the artist.) Thank you, Tom, for sharing more of your work with us.

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A Catalog of Primary Types of Bat Fleas (Siphonaptera: Ischnopsyllidae) of the World

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Introduction

There has been only one publication that attempted to list all genera and species of bat fleas, family Ischnopsyllidae. That report (Hopkins and Rothschild, 1956) was part of a seven-volume series dealing with the Rothschild Collection of fleas in the British Museum (Natural History), originally held at Tring and now in London. Hopkins and Rothschild (1956) dealt with 15 genera and 68 species and included all known species, even if not present in the collection. In the intervening 50 years, five new genera were erected, collectively containing 11 new species. These taxa, plus new species assigned to pre-existing genera, have increased the number of full species in the family to ca. 130.

Historically, it was thought that fleas were less host-specific than other ectoparasites, because of a lack of intimate contact between the hosts and developmental stages of fleas, especially the larvae. This belief has been tempered by new evidence that ecological factors influencing larval development are at least as important, if not paramount, in determining specificity for terrestrial hosts. Flight imposes additional strictures on ecological and behavioral factors supporting the life cycles of fleas that parasitize bats. For example, solitary bats that live in the open seldom, if ever, yield fleas, although acarines and nycteribiid and streblid flies are common. Apparently only bats that associate in small-to-large aggregations provide satisfactory conditions for fleas to reproduce.

Methods

This paper contains an inventory of the primary types of the species of bat flea for the world. In addition to the original descriptions, I depend greatly on the works of Adams and Lewis (1995), Lewis and Lewis (1989), and Smit and Wright (1965, 1978) for details concerning localities, hosts, and depositories of types. For species described during the 19th and early 20th centuries, much of this information often is lacking, and any commentary made by the present author may not be supported by evidence. In an effort to stabilize the nomenclature, it may be appropriate to designate lectotypes when possible and neotypes when no syntypes are known, but I am reluctant to do so in the absence of incontestable evidence concerning the availability of material for these designations. However, as knowledge progresses, this may become a practical solution to many nomenclatural problems.

Each entry in the catalog starts with the name of the taxon and the authority, followed by an abbreviated citation of where the original description was published. An asterisk placed before the name of a taxon indicates that it is the generitype of the genus. The next sentence indicates the capture locality, original host, date of capture, and name of collector, when known, and each entry ends with information concerning the type specimens. The term holotype usually refers to specimens in the British Museum of Natural History or the United States National Museum that were either cited as type or holotype in the original description. Single specimens are treated as holotypes by virtue

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of monotypy. Subsequently designated neotypes or lectotypes are usually accompanied by citations indicating where this action was taken. Abbreviations for various museums where primary types are deposited are explained in Appendix 1.

Catalog

Family: **Ischnopsyllidae** Wahlgren, 1907
Tijdschr. Entomol., 28:89
Type Genus and Species: ***Ischnopsyllus octactenus*** (Kolenati, 1856)

Nom. mut. pro. **Typhlopsyllinae** Tiraboschi, 1904
Arch. Parasitol., 8:273
Type Genus and Species: ***Typhlopsylla octactenus*** Kolenati, 1856
(by subsequent designation of Baker, 1904:371)

Genus: ***Alectopsylla*** Mahnert, 1976
Rev. Suisse. Zool., 83:769

****unisetosa*** Mahnert, 1976. Rev. Suisse Zool., 83:770. **Argentina**, Chabut Province, El Hoyo de Epuyen, 12 km S El Bolson, ca. 42.10S 71.21W, ex *Myotis* aff. *levis*, 19-XII-1975, A. Kovacs. Holotype: **male**, in MHNG.

Genus: ***Allopsylla*** Beaucournu and Fain, 1982
Rev. Zool. Afr., 96:560

alloides (Smit, 1977). Beaufortia, 26:41. **Nigeria**, Agege, 06.38N 03.19E, ex *Tadarida* (*Mops*) *congica*, 28-VIII-1976, W. Bergmans. Holotype: **male** in ZMUA.

****hetera*** Beaucournu and Fain, 1982. Rev. Zool. Afr., 96:562. **Zaïre**, Kasaï Province, 05.54S 22.25E, ex *Galago demidovi* (a bushbaby), collector and date uncertain. Holotype: **male** in MRAC.

Genus: ***Araeopsylla*** Jordan and Rothschild, 1921
Ectoparasites I:146

elbeli Traub, 1954. Proc. Entomol. Soc. Wash., 56:168. **Thailand**, Kanchanaburi, 14.02N 99.32E, Tamoung Bantum, ex *Taphozous melanopogon,* 5-IV-1952, R. E. Elbel. Holotype: **male** in USNM, No. 104618.

faini Beaucournu, 1981. Rev. Zool. Afr., 95:195. **Rwanda**, Nyiakibanda, nr Butare, 02.40S 29.45E, ex *Tadarida pumila,* X-1955, A. Fain. Holotype: **male** in MRAC.

gestroi (Rothschild, 1906). Novit. Zool., 13:187. **Italy**, Genoa, 44.24N 08.56E, ex *Nyctinomus cestonii,* date not given, R. Gestro. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:20).

immanis Smit, 1958a. Entomol. Ber., 18:202. **Cambodia**, Angkor-Vat, 13.26N 103.50E, ex bat guano, I-1956, R. Lumaret. Holotype: **male** by designation, in BMNH.

lumareti Smit, 1958a. Entomol. Ber., 18:199. **Cambodia**, Angkor-Vat, 13.26N 103.50E, ex bat guano, I-1956, R. Lumaret. Holotype: **male** by designation, in BMNH.

martialis (Rothschild, 1903b). Novit. Zool., 10:322. **Reunion Island**, La Plaine des Palmistes, 21.08S 55.38E, ex *Nyctinomus acetabulosus,* date unknown, M. Sikora. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:30).

phnomensis Klein, 1970. Bull. Soc. Entomol. Fr., 74:248. **Cambodia**, Battambang Province, 13.06N 103.13E, Phnom Samrap Reach, ex *Tadarida plicata*, K. Suor and L. Thou. Holotype: **male** in SEIP.

****scitula*** (Rothschild, 1909). Novit. Zool., 16:55. **South Africa**, King William's Town, 32.53S 27.24E, ex *Nyctinomus* *aegyptiacus,* 25-IX-1908, R. Godfrey. Lectotype: **male** in BMNH, designated by Smit and Wright, 1978:41.

wassifi Traub, 1954. Proc. Entomol. Soc. Wash., 56:161. **Egypt**, Giza Province, Abu Rawash, ca. 29.59N 31.07E, ex *Tadarida aegyptiaca,* 3-X-1952, H. Hoogstraal. Holotype: **male** by designation, in USNM, No. 104700.

Genus: ***Chiropteropsylla*** Oudemans, 1908
Tijdschr. Entomol., 51:102

****aegyptia*** (Rothschild, 1903a). Entomol. Mon. Mag., 39:83. **Egypt**, nr Cairo, 30.03N 31.15E, ex *Taphozous perforatus,* 24-I-1901, N. C. Rothschild and A. F. R. Wollaston. Holotype: **female** by monotypy, in BMNH.

brockmani Rothschild, 1915. Entomol. Mon. Mag., 51:304. **Somalia**, Burao, 09.31N 45.33E, ex bats [=*Lavia frons*], 20-IV-1915, R. E. Drake-Brockman. Holotype: **female** by monotypy, in BMNH.

Genus: ***Coorilla*** Dunnet and Mardon, 1973
J. Aust. Entomol. Soc., 12:3

allisoni Mardon, 1986. J. Aust. Entomol. Soc., 25:47. **Australia**, Queensland, 135 mi NW Charleville, 26.03S 145.01E, ex *Mormopterus beccarii,* 21-X-1979, D. S. Reimer and D. H. C. Seton. Holotype: **male** in QMBA.

****longictena*** Dunnet and Mardon, 1973. J. Aust. Entomol. Soc., 12:4. **Australia**, New South Wales, 3 mi from St. Albans, Macdonald River, ex *Tadarida planiceps,* 6-II-1924, C. Friend. Holotype: **male** in ANIC.

similis Mardon and Allison, 1978. J. Aust. Entomol. Soc., 17:167. **Australia**, Queensland, Kirknie via Ayr, 19.32S 147.25E, ex *Tadarida planiceps,* 21-XI-1972, P. M. Johnson and F. R. Allison. Holotype: **male** in QMBA.

Genus: ***Dampfia*** Smit, 1954
Parasitology, Camb., 44:145

****grahami grahami*** (Waterston, 1915). Rec. Albany Mus., Grahamstown, 3:115. **South Africa**, Cape Province, Grahamstown, 33.18S 26.32E, ex *Eptesicus capensis,* IV-1913, collector unstated. Holotype: **male** in AMGS.

grahami equatoris Smit, 1954. Parasitology, Camb., 44:146. **Belgian Congo** (**Zaïre**), Kivu District, *sine loco,* ex small insectivorous bat, no date, G. H. E. Hopkins. Holotype: **male** by designation, in BMNH.

Genus: ***Hormopsylla*** Jordan and Rothschild, 1921
Ectoparasites, I:158

cryptica Tipton and Machado, 1972. Brig. Young Univ. Sci. Bull., Biol. Ser., 17:87. **Venezuela**, SSE Esmeralda, nr Boca Mavaca, 02.30N 65.13W, 185 m, ex *Eptesicus brasiliensis,* 13-II-1966, Tuttle Team. Holotype: **male** by designation, in USNM, No. 72537.

egena Jordan, 1950. Bull. World Health Org., 2:608. **Peru**, La Libertad Department, Trujillo City, 08.06S 79.00W, ex rat burrow inhabited by bats, XII-1947, A. Macchiavello. Holotype: **female** by designation, in BMNH.

****fosteri*** (Rothschild, 1903b). Novit. Zool., 10:324. **Paraguay**, Paraguari Department, Sapucay, 25.40S 56.55W, ex *Molossus bonariensis,* 6-IX-1909, W. Foster. Lectotype: **male** in BMNH, designated by Smit and Wright, 1978:20.

kyriophila Tipton and Méndez, 1966. Ectoparasites of Panama, p. 303. **Panama**, Pacora, ca. 25 mi NE Panama City, 08.59N 79.29W, sea level, ex *Tadarida yucatanica,* 21-VI-1961, C. M. Keenan and V. J. Tipton. Holotype: **male** in USNM, No. 194641.

trux Jordan, 1950. Bull. World Health Org., 2:607. **Peru**, La Libertad Department, Trujillo City, Chinese Cemetary, 08.06S 79.00W, ex bats, 25-VIII-1947, A. Macchiavello. Holotype: **male** by designation, in BMNH.

Genus: ***Ischnopsyllus*** Westwood, 1833
Entomol. Mag., 1:362

Subgenus: (***Ischnopsyllus***) Westwood, 1833
Entomol. Mag., 1:362

consimilis (Wahlgren, 1904). *In* L. A. Jägerskiold, Res. Swed. Zool. Exped., 16:3. **Egypt**, Dagahlia Province, 8 km W Sambillawein, ca. 30.53N 31.27E, ex *Pipistrellus kuhli,* 26-XI-1947, P. Q. Tomich. Neotype: **male** in BMNH, designated by Smit (1954:151).

dolosus Dampf, 1912. Rev. Russe Entomol., 12:41. **Russian Federation**, Caucasus Mountains, Umgebung von Naltshik, Terskisches Gebeit, untraced, ex *Plecotis auritus,* 1890, J. Wagner. Disposition not stated.

****elongatus*** (Curtis, 1832). British Entomol., 9:417. **England**, no locality information, ex yellow bat [=*Vespertilio noctula*], no date or collector. No type designation. In Curtis Collection, location unknown.

emminus Jordan and Rothschild, 1921. Ectoparasites, I:142. **South Africa**, Natal, Greenwood Park, untraced, ex *Vespertilio capensis*, 14-X-1914, R. Boyce. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:18).

hellespontius Peus, 1978. Folia Parasitol., 25:51. **Turkey**, Vilayet Canakkale, Gelibolu, Seddülbahir, 40.03N 26.12E, ex *Myotis nattereri,* 1-VI-1967, F. Spitzenberger and K. Bauer. Holotype: **male** in MHNG.

hispanicus Jordan, 1942. Eos, Madrid, 18:243. **Spain**, Sevilla, 37.24N 05.59W, ex *Myotis nattereri,* date not given, V. L. Seoane. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:23).

intermedius (Rothschild, 1898). Novit. Zool., 5:543. **England**, Yalding, 51.14N 00.25E, ex *Scotophilus serotinus,* 25-V-1898 W. R. O. Grant and S. Ried. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:25).

kilitbahricus Aktas, 1990. Misc. Pap., Ctr. Entomol. Studies, Ankara, 7:4. **Turkey**, Vilayet Canakkale, Kilitbahir, untraced, *Myotis natterei,* 14-VII-1985, M. Aktas. Holotype: **male** deposition unknown.

liae Jordan, 1941. Parasitology, Camb., 33:370. **China**, Kweichow, Kweiyang, 26.35N 106.40E, ex bats, 1-V-1939, K.-C. Li. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:28).

needhami Hsü, 1935. Peking Nat. Hist. Bull., 9:293. **China**, Kiangsu, Soochow, 31.21N 120.40E, ex bats, 8-VI-1934, Y.-C. Hsü. Holotype: **male** in collection of original author, location unknown.

obscurus (Wagner, 1898). Horae Soc. Entomol. Ross, 31:584. **Russian Federation**, Chernovski-Bor Gouvenorate, Woronesh, untraced, ex *Vesperugo discolor,* 7-VI-1896, A. Silantjew. Type: **female** in JWC. Lectotype: **male** in BMNH, designated by Hopkins and Rothschild (1956:268).

octactenus (Kolenati, 1856). Die Parasiten der Chiroptern, p. 31. **Czechoslavia** or **Switzerland**, no location data, ex *Pipistrellus pipistrellus,* date and collector not given, deposition unstated.

peridolius Peus, 1976. Abh. Zool.-Bot. Ges. Wien, 20:21. **Turkey**, Vilyet Rise, Cat, Camlihemsin, Waldgebiet mit Wiesen, 39.40N 41.03E, 260 m, ex *Myotis mystacinus,* 13-VIII-1967, H. Steiner. Holotype: **male** in collection of author, now in MHNG.

plumatus Ioff, 1946. Med. Parasitol. Moskva., 15:93. **Turkmenistan**, location not given but see below. Host not listed but mainly *Pipistrellus* and *Nyctalus* species. Ioff et al. (1965) list specimens from Chu, Kazakhstan, 43.34N 73.44E and Kuska, 35.14N 62.15E, the Afghanistan-Turkmenistan border. Holotype: **male** probably in APIC.

simplex simplex Rothschild, 1906. Novit. Zool., 13:186. **England**, Shepton Montague, 51.05N 02.28W, ex *Vespertilio nattereri*, 17-VIII-1892, A. E. Eaton. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:42).

simplex mysticus Jordan, 1942. Eos, Madrid, 18:244. **Austria**, Ober Österreich, Wels, 48.10N 14.02E, ex *Pipistrellus pipistrellus*, 1910, J. Roth. Holotype: **male** by designation, in BMNH.

variabilis (Wagner, 1898). Horae Soc. Entomol. Ross., 31:582. **Russian Federation**, Woronesch Gouvnorate, Voroneshskaya Oblast, Chernowski-Bor (pine forest at Khrenovoye), 51.08N 40.61E, ex *Pipistrellus nathusii*, 18-VI-1896, A. Silantiew. Lectotype: **male** in ZMUH, designated by Smit and Wright (1965:46).

Subgenus: (***Hexactenopsylla***) Oudemans, 1909
Entomol. Ber. Amst., 3:4

comans Jordan and Rothschild, 1921. Ectoparasites, I:143. **China**, Peking, 39.55N 116.25E, ex *Vesperugo planeyi*, date not given, M. Planey. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:13).

delectabilis Smit, 1952. Ann. Mag. Nat. Hist., 12:844. **India**, Imphal [=Manipur], 24.47N 93.55E, ex *Pipistrellus paterculus*, 25-II-1946, J. Hake. Holotype: **male** by designation, in BMNH.

****hexactenus*** (Kolenati, 1856). Die Parasiten der Chiroptern, p. 13. **Czech Republic** (?). Moravia, locality untraced, ex *Plecotus auratus*, date and collector not given. Types not designated. Hopkins and Rothschild (1956) list records from the British Isles, France, and Holland, east to Czechslovakia, Hungary, and Romania.

indicus Jordan, 1931b. Novit. Zool., 37:147. **India**, Dimja Gali [=Dunga Gali] (a hill station in the SE Hazara District), 34.08N 73.17E, 2700 m, ex *Synotus darjelingensis*, 28-VIII-1907, Ms. Holms-Tarn. Holotype: **female** by designation, in BMNH.

infratentus Wu, Wang, and Liu, 1988. Acta Zootax. Sinica, 13:308. **China**, Gansu Province, Yuzhong County, *sine loco*, ex *Myotis* sp., 16-VII-1981, collector not given. Holotype: **male** in DBLU.

jinciensis Xiao, 1984. Entotaxonomia, 6:247. **China**, Shanxi Province, Jinci, from coal mine S of Taiyuan City, untraced, ex *Plecotus auratus*, 27-IV-1978, collector not given. Holotype: **male** in PSMC.

magnabulga Xie, Yang, and Li, 1983. Entomotaxonomia, 5:116. **China**, Sichuan Province, locality not given, ex bat, V-1963, collector not given. Type not designated; male unknown. Deposition not given, but probably in REYI.

petropolitanus (Wagner, 1898). Horae Soc. Entomol. Ross., 31:586. **Russian Federation**, St. Petersberg Gouvnorate, St. Petersberg, 59.55N 30.25E, ex bat, 1889, J. Wagner. Holotype: **male** in ZMAS.

quadrasetus Xie, Yang, and Li, 1983. Entomotaxonomia, 5:113. **China**, Yunnan Province, Midu, 25.22N 100.33E, ex bats, X-1953, collector not given. Holotype: **male** in RIEY.

quintusetus Xie, Yang and Li, 1983. Entomotaxonomia, 5:114. **China**, Yunnan Province, Xiangyun, 25.29N 100.33E, ex bats, IX-1979, collector not given. Holotype: **male** in RIEY.

shansiensis Liu, Hsing, and Chen, 1981. Acta Entomol. Sinica, 24:317. **China**, Shanxi Province, Yun Chen District, Jie Xian, 36.59N 111.54E, ex *Myotis myotis*, 1975, collector not given. Holotype: **male** in BSMC.

transcaucasicus Scalon, 1979. Entomol. Obozr., 58:901. **Russian Federation**, Gruzinskoi SSR, Aspindzaskii Rayon, Vardizia Monestary, 41.33N 43.14E, ex *Plecotus auritus*, 24-V-1954, V. M. Guseva and I. M. Dzhmukhadze. Holotype: **male** in APIC.

ussuriensis Medvedev, 1986. Entomol. Obozr., 65:436. **Russian Federation**, Kuril'skoi Ostrav, Sakhalinskaya Oblast, Sakhalin Island, Kunashir, untraced, ex *Myotis ikonnikovi*, 8-VII-1985, M. P. Tiunov. Holotype: **male** in ZMAS.

Genus: ***Lagaropsylla*** Jordan and Rothschild, 1921

Ectoparasites, I:152

anciauxi Smit, 1957b. Rev. Zool. Bot. Afr., 56:263. **Zaïre**, Katanga Province, Mwadingusha, 10.23S 27.14E, ex *Tadarida ansorgei*, 1957, F. Anciaux-Faveaux. Holotype: **male** in MRAC.

consularis Smit, 1957a. Rev. Zool. Bot. Afr., 55:167. **Ethiopia**, Harar, 09.20N 42.10E, ex *Tadarida pumila*, 24-25-I-1927, H. Scott. Holotype: **male** in MRAC.

convexus Segerman, 1973. Novos Taxa Entomol., 102:3. **Ghana**, Ashanti Region, Ahiriso, untraced, ex *Tadarida thersites*, 29-I-1968, H. W. Setzer. Holotype: **male** by designation, in USNM, No. 72475.

duodecima Beaucournu and Kock, 1990. Senckenberg. Biol., 70:78. Togo, no other locality data, ex *Tadarida pumila*, 1899, collector unknown. Holotype: **male** in JCBC.

hoogstraali Smit, 1957a. Rev. Zool. Bot. Afr., 55:172. **Sudan**, Equatoria Province, Torit, 04.27N 32.31E, 650 m, ex molossid, 25-I-1951, H. Hoogstraal. Holotype: **male** by designation, in BMNH.

idae Smit, 1957a. Rev. Zool. Bot. Afr., 55:165. **Malawi**, Karonga, 09.54S 33.55E, ex house bats, 31-X-1919, W. A. Lamborn. Holotype: **male** in BMNH.

incerta (Rothschild, 1900). Entomol. Rec. J. Var., 12:38. **Madagascar**, Tamatave, 18.10S 49.23E, ex *Nyctinomus juglandaris*, no date, W. D. Cowan. Holotype: **male** in BMNH.

leleupi Smit, 1957b. Rev. Zool. Bot. Afr., 56:265. **Zaïre**, Urundi, Bugasera, untraced, ex *Tadarida angolensis*, IX-1957, L. Leleup. Holotype: **male** in MRAC.

lipsi Smit, 1957a. Rev. Zool. Bot. Afr., 55:170. **Belgian Congo [Zaïre]**, Katanga Province, Elizabethville Region, Kiswishi, untraced, ex *Tadarida spillmanni*, VII-1956, Lips leg. Holotype: **male** in MRAC.

malayana Beaucournu and Kock, 1994a. Senckenberg. Biol., 73:68. **Malaysia**, Negri Sembilan Province, Kuala Pilan, ca. 02.44N 102.15E, ex *Tadarida plicata*, 29-IX-1966, A. J. Beck. Holotype: **male** in SMFD.

mera mera Jordan and Rothschild, 1921. Ectoparasites, I:156. **Java**, *sine loco*, ex *Vespertilio* sp., no date, G. C. Shortridge. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:30).

mera australiaca Beaucournu and Kock, 1994b. Ann. Soc. Entomol. Fr. (N. S.), 30:201. **Australia**, Western Australia, Mount Hart, 16.55S 125.05E, ex *Tadarida jobensis*, 11-IX-1976, Kimberly Expedition. Holotype: **male** by designation, in BMNH.

micula Jordan and Rothschild, 1921. Ectoparasites, I:154. **Burma**, South Tenasserim, 12.24N 98.37E, ex *Nyctinomus tragatus,* 1914, G. C. Shortridge. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:31).

mytila Hurka, 1984. Acta Entomol. Bohemoslov., 81:204. **Vietnam**, Ho Chi Min City [=Saigon], 10.46N 106.43E, ex *Tadarida plicata,* 11-XI-1979, J. Zeleny. Holotype: **male** in SZCU.

obliqua Smit, 1957a. Rev. Zool. Bot. Afr., 55:169. **Sierra Leone**, *sine loco*, ex *Nyctinomus brachypterus,* no date, Hart leg. Holotype: **male** by designation, in BMNH.

putila Jordan and Rothschild, 1921. Ectoparasites, I:154. **India**, Guindy, a suburb of Madras, 13.00N 80.17E, ex *Nyctinomus plicatus,* III-1910, W. S. Patton. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:38).

****signata*** (Wahlgren, 1903). Arkiv för Zoologi, 1:189. **Indonesia**, Java, nr Banjuwengi, Bali Sunde, untraced, ex *Tadarida plicata,* 22-V-1899, C. Aurivillius. Type not designated, location unknown.

taeniolae Smit, 1965. Rev. Zool. Bot. Afr., 72:137. **Ghana**, Wenchi, 07.44N 02.09W, ex roost of *Tadarida major,* 30-IV-1963, F. R. Allison. Holotype: **male** by designation, in BMNH.

tauffliebi Smit, 1962. Rev. Zool. Bot. Afr., 66:195. **Central African Republic**, nr Bangui, 04.23N 18.37E, Oubangi Chari, ex *Tadarida* sp., X-1961, R. Taufflieb. Holotype: **male** by designation, in BMNH.

turba Smit, 1958b. Entomol. Ber. Amst., 18:238. **Malaysia**, Sarawak, cave at Niah, 03.54N 13.41E, ex *Cheiromeles torquatus,* 1-IV-1957, Lord Medway. Holotype: **male** by designation, in BMNH.

Genus: ***Mitchella*** Lewis, 1970
J. Parasitol., 56:146

****exsula*** Lewis, 1970. J. Parasitol., 56:148. **Nepal**, Bagmati Zone, Sindu District, Uring Ghayang, 28.01N 65.30E, 3498 m, ex *Pipistrellus* sp., 6-IX-1968, R. M. Mitchell. Holotype: **female** by designation, in USNM No. 70841.

laxisinuata (Liu, Wu, and Wu, 1977). Acta Entomol. Sinica, 20:233. **China**, Xizang, Bai Cun Ji-gung, Bomi, Xian Zizhigu, 29.56N 95.45E, ex bats, X-1964, collector not given. Holotype: **female** in AMMS.

megatarsalia (Liu, Wu, and Wu, 1977). Acta Entomol. Sinica, 20:233. **China**, Xizang, Bai Cun, Ji-gung, Bomi, Xian Zizhigu, 29.56N 95.45E, ex bats, X-1964, collector not given. Holotype: **male** in AMMS.

truncata (Liu, Wu, and Wu, 1977). Acta Entomol. Sinica, 20:233. **China**, Xizang, Bai Cun, Ji-gung, Bomi, Xian Zizhigu, 29.56N 95.45E, ex bats, X-1964, collector not given. Holotype: **male** in AMMS.

Genus: ***Myodopsylla*** Jordan and Rothschild, 1911
Novit. Zool., 18:88

borealis Lewis, 1978. J. Parasitol, 64:524. **USA**, Montana, Carter County, 10 km N, 16 km W of Camp Crook, South Dakota, 45.39N 104.04W, 1158 m, ex *Eptesicus fuscus,* 11-VII-1907, R. A. Winstel. Holotype: **male** by designation, in USNM, No. 75437.

collinsi Kohls, 1937. J. Parasitol., 23:300. **USA**, Santa Cruz County, Santa Rita Mountains, Madera Canyon, ca. 31.45N 110.48W, ex bat, 9-V-1933, G. M.

Kohls. Holotype: **male** by designation, in USNM, No. 104604.

gentilis Jordan and Rothschild, 1921. Ectoparasites, I:152. **Canada**, Okanagan Landing, 50.12N 119.22W, ex bat, 19-IX-1912, J. A. Monro. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:20).

globata Holland, 1971. Can. Entomol., 103:95. **Mexico**, Chiapas, ca. 11 km E San Cristobal de las Casas, ca. 16.45N 92.31W, 2134 m, ex *Myotis velifer* or *Tadarida brasiliensis,* 16-V-1969, J. H. E. Martin. Holotype: **female** in CNCI.

****insignis*** (Rothschild, 1903b). Novit. Zool., 10:319. **Canada**, Ontario, Waterloo, 43.28N 80.32W, ex *Myotis lucifugus,* 2-VII-1900, G. F. Dippie. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:2).

isidori (Weyenbergh, 1881). Period. Zool., 3:271. **Argentina**, *sine loco,* ex *Vespertilio isodon,* date unknown, H. Weyenbergh. Lectotype: **male** in BMNH, designated by Hopkins and Rothschild (1956:244).

nordina Traub and Hoff, 1951. Amer. Mus. Novit., 1530:11. **USA**, New Mexico, Bernalillio County, nr Isleta, 34.55N 106.43W, ex *Myotis thysanoides,* 25-VII-1949, E. Mann. Holotype: **male** in AMNH.

palposa (Rothschild, 1904). Novit. Zool., 11:652. **Canada**, Vancouver Island, Cowichan, Duncans, 45.50N 124.04W, ex brown bat labeled *Vespertilio fuscus,* 4-VIII-1903, A. Brooks. Lectotype: **female** in BMNH, designated by Smit and Wright (1978:35).

setosa Johnson, 1956. J. New York Entomol. Soc., 62:193. **Peru**, Huancavelica Department, Yucay, 13.19S 74.16W, ex bat, 29-XII-1937, J. Soukup. Holotype: **male** by designation, in USNM, No. 63289.

trisellis Jordan, 1929b. Novit. Zool., 35:162. **China**, Manchuria, N of Nen-chiang [=Mergen], Charithun, 49.11N 125.13E, ex *Pipistrellus* sp., 19-VII-1928, H. M. Jettmar. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:48).

tropica Méndez and Lemke, 1979. Proc. Entomol. Soc. Wash., 81:657. **Colombia**, Huila Department, Parque Nacional de la Cueva de los Guácharos, Cueva del Indio, ca. 03.00N 75.59W, 1900 m, ex *Myotis oxyotis,* 3-VI-1976, T. Lemke. Holotype: **male** by designation, in USNM, No. 104263.

wolffsohni wolffsohni (Rothschild, 1903b). Novit. Zool., 10:321. **Paraguay**, Paraguari Department, Tacuarals, 26.38S 57.56W, ex *Myotis albescens,* 12-XI-1900, W. Foster. Holotype: **male** in BMNH, designated by Smit and Wright (1978:50).

wolffsohni salvasis Jordan, 1931a. Z. Parasitenk., 3:264. **Venezuela**, Mérida, 08.24N 71.08W, ex bat, W. F. H. Rosenberg. Holotype: **male** by designation, in BMNH.

Genus: ***Nycteridopsylla*** Oudemans, 1906
Tijdschr. Entomol., 49:lviii

ancyluris ancyluris Jordan, 1942. Eos, Madrid, 18:248. **Italy**, Firenze [=Florence], 43.47N 11.15E, ex *Pipistrellus savii,* 3-III-1916, N. Cimbali. Holotype: **male** by designation, in BMNH.

anacyluris johanae Hurka, 1970. Acta Universitatis Carolinae, Biol., 1969:21. **Bulgaria**, Cave Suchata Pestera, nr Lakatnik, untraced, ex *Pipistrellus pipistrellus,* 15-I-1966, J. Hurkova and I. Hrdy. Holotype: **male** in collection of author, probably SCZU.

calceata Ioff and Labunets, 1953. Med. Parasitol., Moskva, 1953:465. **Russian Federation**, Central Asia, Uzbekistan, nr Tashkent, ca. 41.16N 69.13E, ex *Vespertilio pipistrellus*, date not given, O. P. Bogdanov and Yu. Muratbekov. Type not designated, but probably in APIC.

chapini Jordan, 1929a. Novit. Zool., 35:390. **USA**, Maryland, Montgomery County, Glen Echo, 38.59N 77.09W, ex *Eptesicus fuscus*, 31-III-1916, R. C. Shannon. Holotype: **male** by designation, in USNM, No. 41423.

dicondylata Wang, 1959. Acta Entomol. Sinica, 9:269. **China**, North Fukien Province, *sine loco*, ex *Pipistrellus abramus*, 3-?-1957, collector not given. Holotype: **male** designated but depository uncertain.

dictena (Kolenati, 1856). Parasiten der Chiroptern, p. 32. Ex *Vespertilio murinus*. No other information about collections, hosts, or types. Since reported from various localities in eastern Europe (i.e., Czechoslovakia, Germany, and Romania).

eusarca Dampf, 1908. Schr. Phys.-Öken. Ges. Königs., 48:398. **Yugoslavia**, Macedonia, Struga, 41.10N 20.41E, Westprussia, ex *Delichon urbica*, a bird, true host *Nyctalus noctula*, date not given, Speiser leg. Types not designated. Hopkins and Rothschild (1956) list specimens from the British Isles, Germany, and Denmark.

galba Dampf, 1910. Zool. Anz., 36:11. **China**, Shanghai Province, 31.13N 121.25E, ex bat, V-1910, Schumaker leg. Lectotype: **male** in BMNH, designated by Hopkins and Rothschild (1956:233).

iae Beaucournu and Kock, 1992. Senckenberg. Biol., 72:330. **Thailand**, Chiang Mai Province, 25 km NW Fang, Mae Teng Region, Pha Hom Pok Mountain, 19.53N 99.13E, 450 m, ex *Ia io*, 6-I-1981, C. Felton. Holotype: **male** in SMFD.

intermedia Lewis and Wilson, 1982. J. Med. Entomol., 19:606. **USA**, Texas, Brewster County, Big Bend National Park, Mt. Emory Cave, ca. 29.15N 103.90W, 2121 m, ex *Plecotus townsendii*, 21-I-1980, G. V. Oliver, Jr. Holotype: **male** by designation, in USNM, No. 100223.

levantina Jordan, 1942. Eos, Madrid, 18:248. **Cyprus**, Nicosea, 31.10N 33.22E, ex *Pipistrellus kuhli*, no date, J. Bucknell. Holotype: **female** by designation, in BMNH.

longiceps Rothschild, 1908. Entomologist, 41:281. **England**, Hertfordshire, Welwyn, 51.50N 00.13W, ex *Scotophilus pipistrellus*, 10-VI-1898, W. R. O. Grant. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:29).

liui Wu, Chen, and Liu, 1988. Acta Zootax. Sinica, 13:172. **China**, Sichuan Province, Barkham County, ca. 31.42N 102.20E, ex *Murina auratus*, 17-IV-1982, collector not given. Holotype: **male** in AHAS.

nipopo Sakaguti and Jameson, 1959. Japanese J. Sanit. Zool., 10:229. **Japan**, Hokkaido Island, Ishikari-no-kuni, Bibai, 43.21N 141.53E, ex bat, 1-X-1958, S. Takatsu. Holotype: **male** in Sakaguti Collection, location unknown.

oligochaeta Rybin, 1961. Trudy Nauchno-issled. Protivochumnogo Inst. Kavkaza i Zakavkaz'ya, 5:206. **Kyrgysan** [=Kirgiziya], Osh, 40.37N 72.49E, ex *Barbastella darjelingensis*, 1-8-II-1955. Holotype: **male** in APIC.

****pentactena*** (Kolenati, 1856). Parasiten der Chiroptern, p. 32. Ex *Plecotus auritus*, no other data. Hopkins and Rothschild (1956:224) list material from Belgium, Germany, Holland, Hungary, Italy, Poland, and Switzerland. Evidently *P. auritus* is the preferred host.

quadrispina Lu and Wu, 2003. Syst. Parasitol., 56:57. **China**, Hubei Province, Badong County, Duizi, ca. 31.03N 110.24E, 400 m, ex *Ia io,* 15-XI-2001, G. Tianyu. Holotype: **female** in AMMS.

sakagutii Jameson and Suyemoto, 1955. Japanese J. Sanitary Zool., 6:19. **South Korea**, Taegu, 35.52N 128.36E, ex *Pipistrellus saveii,* 2-II-1954, J. P. Kramer. Holotype: **male** by designation, in USNM, No. 62954.

singula Rybin, 1991. Parasitologia, 25:172. **Kyrgystan** [=Kirgizia], Oshskaya Oblast, Vusota, Kanigut Cave, untraced, 2000 m, ex *Barbastella leucomelas,* 18-V-1990, collector not given. Holotype: **male** in ZMAS.

trigona trigona Ioff and Labunets, 1953. Med. Parasitol. Moskva, 1953:465. **Russian Federation**, Central Asia, Uzbekistan, nr Tashkent, ca. 41.16N 69,13E, ex *Barbastella darjelingensis,* date not given, O. P. Bogdanov and Ya. M. Muratbekor. Type not designated, probably in APIC.

trigona balkanica Hurka, 1965. Acta Entomol. Bohemoslov. Praha, 62:496. **Bulgaria**, Lakatnik, Sukhata Peshtera cave, untraced, ex *Plecotus austraicus,* 10-II-1965, K. Hurka. Holotype: **male** in collection of author, location unknown.

vancouverensis Wagner, 1936. Z. Parasitenk., 8:658. **Canada**, British Columbia, Vancouver, 41.13N 123.06W, ex *Lasionycteris noctivagans,* 5-V and 25-X-1935, G. J. Spencer. "Typus" [=holotype: **male**] said to be in the University of British Columbia Collection [SMDV] but untraced by Holland.

Genus: ***Oxyparius*** Jordan, 1936
Novit. Zool., 40:86

****isomalus*** (Waterston, 1915). Rec. Albany Museum, Grahamstown, 3:109. **South Africa**, Cape Province, cave near Pretoria, ca. 25.45S 28.12E, ex *Mineopterus* sp. or *Rhinolophus angur,* X-1910, K. And. leg. Holotype: **female** in AMGS.

Genus: ***Porribius*** Jordan, 1946
Trans. R. Soc. N. Z., 76:208

bathyllus (M. Rothschild, 1936). Novit. Zool., 40:14. **Australia**, Western Australia, 150 mi N Perth, Carnamah, 29.42S 115.53E, ex *Nyctinomus australis*, 1927, L. Glauert. Lectotype: **female** in BMNH, designated by Smit and Wright (1978:8).

****caminae*** (Rothschild, 1903b). Novit. Zool., 10:323. **Australia**, Western Australia, Bannertel, untraced, ex bat, 20-IX-1900, B. Woodward. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:10).

pacificus Jordan, 1946. Trans. Proc. R. Soc. N. Z., 76:209. **New Zealand**, Pelorus Islands, Pelorus Valley, untraced, ex *Chalinolobus morio*, date and collector not given. Holotype: **male** by designation, in BMNH.

papuanus Holland, 1969. Mem. Entomol. Soc. Canada, 61:12. **New Guinea**, Maneau Range, Mount Dayman, untraced, 2230 m, ex bat, 18-VI-1953, H. M. Van Dusen. Holotype: **male** in AMNH.

Genus: ***Ptilopsylla*** Jordan and Rothschild, 1921
Ectoparasites, I:158

****leptina leptina*** Jordan and Rothschild, 1921. Ectoparasites, I:160. **Paraguay**, Santissima [=Santisima], Trinidad, a suburb of Asuncion, 25.15S 57.38W, ex bat, no date, L. Zürcher. Holotype: **male** by designation, in BMNH.

leptina dunni Kohls, 1942. J. Parasitol., 28:361. **Panama**, Panama Province, Panama City, 08.56N 79.32W, ex *Molossus coibensus,* 6-XII-1933, L. H. Dunn. Holotype: **male** by designation, in USNM, No. 104616.

leptina stubbei Smit, 1971. Mitt. Zool. Mus. Berl., 47:269. **Mexico**, Veracruz, 19.11N 96.10W, ex *Molossus ater*, 29-X-1967, M. Stubbe. Holotype: **male** by designation, in BMNH.

Genus: ***Rhinolophopsylla*** Oudemans, 1909
Entomol. Ber. Amst., 3:3

ashworthi (Waterston, 1913). Proc. R. Phys. Soc. Edinb., 19:12. **South Africa**, Pirie, King William's Town, 32.53S 27.24E, ex *Rhinolophus angur*, 17-XI-1911, F. Ross. Holotype: **female** by designation, in BMMH.

capensis Jordan and Rothschild, 1921. Ectoparasites, I:148. **South Africa**, Zululand, Mfongosi [=Mfongozi], 28.42S 30.49E, ex *Nycteris capensis,* IX-1914, W. E. Jones. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:11).

ectopa (Jordan, 1937b). Novit. Zool., 40:331. **Kenya**, Mt. Elgon, in cave at Kapretwa, 01.07N 34.35E, 3700 m, ex *Mineopterus natalensis,* II or III-1935, British Museum Ruwenzori Expedition. Holotype: **male** by monotypy, in BMNH.

****unipectinata unipectinata*** (Taschenberg, 1880). Die Flöhe, p. 92. **Switzerland**, ex *Rhinolophus hipposideros,* no other data. Types unknown.

unipectinata arabs Jordan and Rothschild, 1921. Ectoparasites, I:147. **Algeria**, Guelt-es-Stel, Hautes Plateaux, 34.20N 03.00E, ex *Rhinolophus ferrumequinum*, 17-IV-1912, K. Jordan. Holotype: **male** by designation, in BMNH.

unipectinata indica Jordan and Rothschild, 1921. Ectoparasites, I:147. **India**, Simla, Himashal Pradesh, 31.07N 77.09E, 2300 m, ex bats, 1-VII-1912, P. T. Dodsworth. Holotype: **male** by designation, in BMNH.

unipectinata turkestanica Ioff, 1953. Med. Parasitol. Moskva, 1953:465. **Russian Federation**, Central Asia, nr Tashkent, 41.16N 69.13, host and date not given, O. P. Bogdanov and Ya. M. Muratbekov. Type not designated, probably in APIC.

Genus: ***Rothschildopsylla*** Guimarães, 1953
Pap. Avuls. Dept. Zool. S. Paulo, 11:109

****noctilionis*** (Costa Lima, 1920). Revista des Sciencias, 4:56. **Brazil**, Corumbá, Matto Grosso, 19.00S 57.35W, ex *Noctilio albiventer,* date not given, A. Miranda Ribeiro. Holotype: **male** by monotypy, deposition not given.

Genus: ***Serendipsylla*** Smit, 1975.
J. Entomol. (B), 42:283.

****marshalli*** Smit, 1975. J. Entomol. (B), 42:284. **Australia** (Central), *sine loco,* ex *Macroderma gigas,* 1892, E. C. Stirling. Holotype: **female** in BMNH.

Genus: ***Sternopsylla*** Jordan and Rothschild, 1921
Ectoparasites, I:158

distincta distincta (Rothschild, 1903b). Novit. Zool., 10:325. **Paraguay**, Guiara Department, Villa Rica [=Villarrica], 25.45S 56.26W, host not given, 31-X-1900, W. Foster. Holotype: **female** by monotypy, in BMNH.

distincta speciosa Johnson, 1957. Mem. Entomol. Soc. Wash., 5:100. **Peru**, Cuzco Department, Quince Mil, 13.15S 70.41W, ex *Tadarida brasiliensis*, 19-VI-1950, V. Kalinowski. Holotype: **male** in FMNH.

distincta texana (Fox, 1914). Bull. Hygenic Lab., Wash., 97:16. **USA**, Texas, Reeve County, Pecos, 31.25N 103.30W, ex *Tadarida brasiliensis,* 21-III-1902, collector not given. Holotype: **female** in USNM, No. 18459.

Subfamily **Thaumapsyllinae** Jordan, 1947
Proc. Entomol. Soc. Wash., 49:182

Genus: ***Thaumapsylla*** Rothschild, 1907
Novit. Zool., 14:329

breviceps Rothschild, 1907. Novit. Zool., 14:329. **South Africa**, Cape Colony, ex *Rousettus collaris,* date and collector not given. Lectotype: **male** in BMNH, designated by Smit and Wright (1978:9).

dina Jordan, 1937a. Novit. Zool., 40:290. **Congo [Zaïre]**, Kaloni [Kalonge] 00.20N 29.48E, 2000 m, W slope of Mt Ruwenzori, ex *Rousettus lanosus,* J. P. Chapin. Holotype: **male** by monotypy, in BMNH.

longiforceps Traub, 1951. Proc. Biol. Soc. Wash., 64:15. **Philippine Islands**, Mindanao, Davao City, 07.05N 125.38E, Luangby Cave, ex *Rousettus* sp., 22-X-1946, H. Hoogstraal. Holotype: **male** in FMNH.

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Appendix 1

Abbreviations for institutions in which primary types were deposited followed the system proposed by Arnett et al. (1993) when possible. Abbreviations are AHAS, Aba Zhang Health and Antiepidemic Station, Sichuan, China; AMGS, Albany Museum, Grahamstown, South Africa; AMMS, Academy of Military Medical Sciences, Beijing, China; AMNH, American Museum of Natural History, New York, USA; ANIC, Australian National Insect Collection, Canberra, Australia; APIC, Antiplague Institut of the Caucasus, Stavropoh'l, Russian Federation; BMNH, British Museum of Natural History, London, England; BSMC, Biology Department, Shanxi Medical College, Shanxi, China; CNCI, Canadian National Insect Collection, Ottawa, Canada; DBLU, Department of Biology, Universty of Gansu, Lanthou, China; FMNH, Field Museum of Natural History, Chicago, USA; JCBC, Jean–Claude Beaucournu Collection, Rennes, France; MHNG, Museum d'Histoire Naturelle de Genevé, Switzerland; NRAC, Musée Royal de l'Afrique Central, Tervuren, Belgium; PSMC, Parasitology Department, Shanxi Medical College, Shanxi, China; QMBA, Queensland Museum, Brisbane, Australia; REYI, Research Institute of Epidemic Diseases of Yunnan, Yunnan, China; SCZU, Systematic Zoology, Charles University, Praha, Czech Republic; SEIP, Service d'Entomologie Medicale â l'Institut Pasteur, Paris, France; SMDV, University of British Columbia, Vancouver, British Columbia; SMFD, Forshungsinstitut and Natur–muesum, Senckenberg, Germany; USNM, United States National Museum, Washington, USA; ZMAS, University of Leningrad, St; Petersberg, Russian Federation; ZMUH, Universitat von Hamburg, Hamburg, Germany; and ZUMA, Zoölogisch Museum, Amsterdam, The Netherlands.

Letters to the Editor

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

Banded Bat Recovered at Wind Farm – Information Needed

Robert Barclay

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The carcass of a hoary bat (*Lasiurus cinereus*) was recently recovered from under a wind turbine in southern Alberta, Canada. The band is unusual in being made of cloth or bandage material. It is soft and flexible and placed around the bat's forearm by being threaded through a small slit in the wing membrane (Fig. 1). The band material is white with the red number 143 written on it.

This is the first banded bat recovered under any wind turbine and offers the opportunity to gain information about the migration patterns of this species. If anyone has information about when and where this bat was banded, please contact:

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This recovery also points out that recovery of banded bats at wind farms may prove to be useful in providing information about the migratory behavior of several species of bats in North America. Those involved in research at wind farms should be on the lookout for banded individuals.

Figure 1. Photograph of band on carcass of a hoary bat recovered from under a wind turbine in Alberta, Canada.

A Fossil Bat with Extremely Worn Teeth and a Question for Tropical Bat Specialists

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Palaeophyllophora is a European genus of bat known only from fossils taken from Paleogene deposits. It possesses archaic skeletal and dental characteristics and appears related to *Hipposideros*. In a paleokarstic area within the region of Quercy, in southwest France, this genus is represented by parallel specific lineages that occurred along a dense sequence of faunas, spanning the late Eocene and Oligocene epochs. Along this sequence and within different lineages, many successive populations of *Palaeophyllophora* are documented by rich collections of upper and lower toothrows, isolated teeth, skulls, and other skeletal material.

Individuals from these populations of *Palaeophyllophora* characteristically show a high proportion of worn teeth. Among all local collections of *Palaeophyllophora*, regardless of species, the youthful state with unworn teeth is rare, whereas teeth that are markedly to extremely worn (tabular) dominate. In contrast, fossil bats from other families and genera typically display variable states of tooth wear, similar to what is seen in large samples of extant species of bat; in other words, a few teeth show little or no wear, most are moderately worn to varying degrees, and a few appear very worn.

Such a disproportionate number of greatly worn teeth in *Palaeophyllophora* is unusual among insectivorous bats and obviously implies that these animals consumed an abrasive kind of food. What formed their diet? Could it have been arthropods with hard, perhaps mineralized tissues, prey that were closely linked to siliceous plant, or maybe terrestrial invertebrates living on or within the soil that retained mineral particles within their digestive tracts? Some extant bats frequently hunt on the ground (e.g., some carnivorous megadermatids and phyllostomids) or even dig burrows (*Mystacina*), but as far as we know, these modern bats are not characterized by extremely worn teeth.

The environment in Quercy during the Paleogene, especially during the late Eocene epoch, was that of a warm and wet tropical forest situated on a wide limestone plateau with developed karstic structures. Wet tropical forests still cover large areas of the world, and such areas contain a large diversity of extant bats. Scientists currently in the field and/or with extensive knowledge of living tropical bats are the most likely persons to answer our question concerning the diet of *Palaeophyllophora*. If any colleagues know of a living species characterized by extremely worn teeth, would you be kind enough to look at some fresh dead specimens, open their stomachs, and identify the abrasive items? We warmly thank you in advance.

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., e-mail: 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 e-mail. 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

Submitted by David Saugey, U.S.F.S. Ouachita National Forest, Jessieville, AR:

Tadarida brasiliensis, the Brazilian free-tailed bat, is now the official flying mammal of the state of Oklahoma. To read the complete story (published 14 April 2006 in The McAlester News-Capital, McAlester, OK, copyright 2006), go to the following URL http://www.mcalesternews.com/statenews/cnhinsall_story_104154848.html and scroll down to "State batty over official mammal."

Submitted by Kunwar Bhatnagar, University of Louisville, Louisville, KY:

Bat guano is back in the news. The Associated Press recently published a story about a farmer from southeast Ohio who collects bat guano from local area churches and sells it as fertilizer. To read the complete story (published 4 July 2006 in The Repository, Canton, OH, copyright 2006), go to the following URL: http://www.cantonrep.com/index.php?ID=294962&Category=13

Thanks, David and Kunwar, for sharing these stories!

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).

ANNOUNCEMENTS

Bat Conservation International—2007 Student Scholarship Program

Bat Conservation International is now accepting applications for its 2007 BCI Student Research Scholarships. Ten to fifteen grants of up to $5,000 will be made in 2007. These grants 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 are eligible to apply (no geographic limitations).

Additional scholarships (supported by the U.S. Forest Service's International Programs) also will be available. These scholarships, however, are specifically designated for research conducted only in developing countries (i.e., geographic limitations apply to these additional scholarships).

All projects must be relevant to bat conservation. The application deadline for all 2007 scholarships is 15 December 2006. Information and forms are available at the following URL: http://www.batcon.org/bcigrants/scholarintro.asp

FUTURE MEETINGS and EVENTS

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

August 19–23, 2007
The 37th Annual NASBR will be held in Merida, Yucatan, Mexico, 19–23 August 2007. For more information, please check the NASBR website (http://www.nasbr.org/).

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

August 2011
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BAT RESEARCH NEWS

VOLUME 47: No. 3 **Fall 2006**

Table of Contents

Letters to the Editor

Front Cover Illustration

Mexican long-tongued bat, *Choeronycteris mexicana*, by Fiona A. Reid. This distinctive nectar-feeding bat occurs in the southwestern U.S. It has a very long tapered muzzle, a small noseleaf, and a short tail. From: A Field Guide to the Mammals of North America north of Mexico, by Fiona A. Reid. 2006. Houghton Mifflin Co., Boston. Illustrations copyright Fiona A. Reid (reproduced with permission from the artist).

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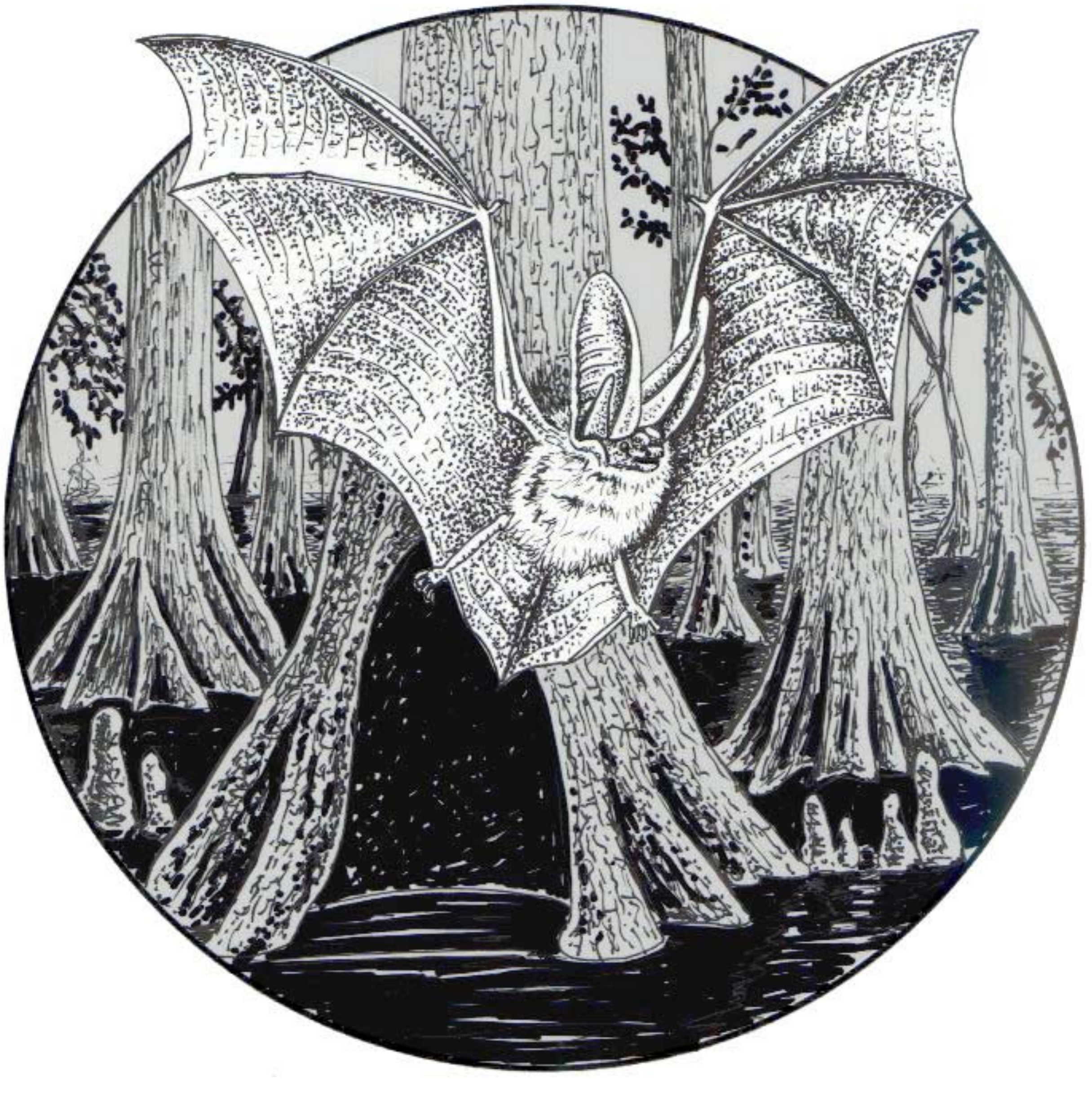

VOLUME 47: No. 4 WINTER 2006

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Detecting Directional Movement at a Hibernaculum with an Infrared Beam-break System

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Abstract

We developed an infrared beam–break detection system to distinguish directional movement of bats entering and leaving the Neda Mine, Dodge Co., Wisconsin, as part of long-term monitoring. With monthly maintenance, data are recorded 24 h/day, 365 days/year. In addition, the system is currently being used to census net movement of bats. The system is flexible enough to be used at other roosting sites and for other directional counting purposes. We describe the system and provide schematic drawings for construction.

Introduction

The Neda Mine State Natural Area, in Dodge Co., Wisconsin, supports one of the largest known populations of hibernating bats in North America (Tuttle, 1996). In January 1995, the population estimate included at least 300,000 little brown bats (*Myotis lucifugus*) and hundreds of northern long-eared bats (*M. septentrionalis*), eastern pipistrelles (*Pipistrellus subflavus*), and big brown bats (*Eptesicus fuscus*—J. S. Altenbach, in litt.). However, the Neda Mine presents multiple challenges for monitoring activity of such a large number of animals over a long period. For example, the mine contains multiple openings that allow access for bats and has more than 6 km of underground tunnels, with many cracks and crevices that conceal these small mammals. These factors alone make long-term monitoring with traditional methods (Thomas and LaVal, 1988) impractical.

Although previous studies proposed use of electronic devices to measure activity and/or count bats (Böhme et al., 1967; DeCoursey and DeCoursey, 1964; Kielmann and Laufens, 1968; Kolb, 1959; Voûte et al., 1974), none was suitable for our long-term goals at the Neda Mine. For example, a beam–break detector was used to monitor activity at a hibernaculum harboring a small number (4,000–6,000) of bats in Denmark (Degn et al., 1995). That system, however, was installed over a small opening (25 by 28 cm); furthermore, there was no description of performance, and no schematic diagrams were provided to reproduce the system. Thus, potential use of the Danish system for larger openings or for long-term monitoring is unclear. In this paper, we describe a system that we developed for the Neda Mine and detail information that is needed to reproduce the system at other hibernacula (Appendix I).

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Description

Four adits (horizontal access tunnels) and one airshaft at the Neda Mine have bat-compatible gates. Each adit also is fitted with a plywood baffle, having a framed central opening bordered by four infrared-detector units (Figs. 1–2). This abandoned iron mine is a high-moisture environment, so all electronics are carefully enclosed and sealed to remain dry. A marine adhesive (Amazing GOOP Marine; Eclectic Products, Eugene, Oregon) works well in situations that require resistance to outdoor conditions.

To ensure alignment of detectors, units are mounted on a metal frame attached to the baffle. A detector unit (Appendix I) consists of an infrared emitter facing an infrared detector on the opposite side of the frame. Units are spaced vertically, 15 cm apart (on center), and detect bats that fly through the opening and break one of the infrared beams. The 15-cm distance reduces the possibility of a single bat breaking more than one beam; however, it is possible for a bat to fly through the framed opening without breaking any beam.

The bat's flight direction is determined by the logical break sequence of two infrared sensors (phototransistors). These two phototransistors, situated side by side on the circuit board of the detector, sense infrared light from the emitter that is located on the opposite side of the frame. The

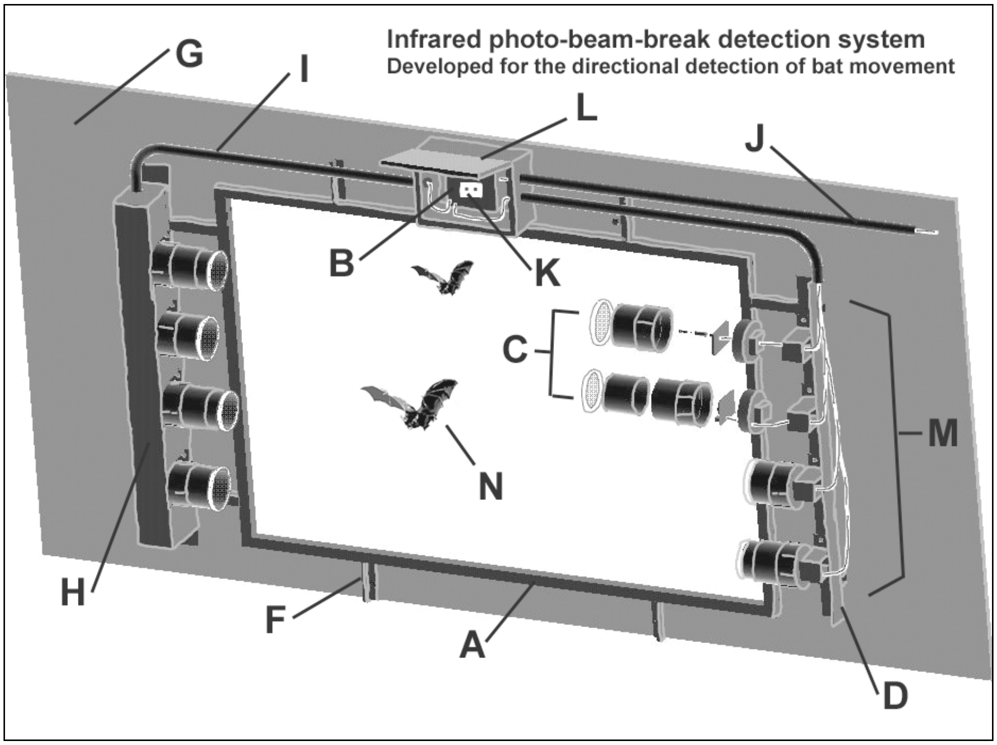

Figure 1. Diagram of electronic housing units: A) metal frame welded from 1-inch square tubing; B) waterproof enclosure for combiner board; C) apparatus that is detailed in Fig. 2; D) 2-inch by 2-inch angle to attach C to A; F) angle-iron tabs welded to A for mounting entire system to plywood baffle; G) plywood sheet (baffle) with opening to ensure N; H) enclosure made of sheet metal to prevent damage to wire cable by animals; I) flexible conduit to prevent damage to wire by rodents; J) power wire and data cable from combiner board to data logger; K) viewing window to see LEDs on combiner board; L) plywood enclosure to hold combiner board enclosure and access wire cable; M) exposed view of wiring that gets enclosed by H; and N) bat that is forced to fly through the detection opening.

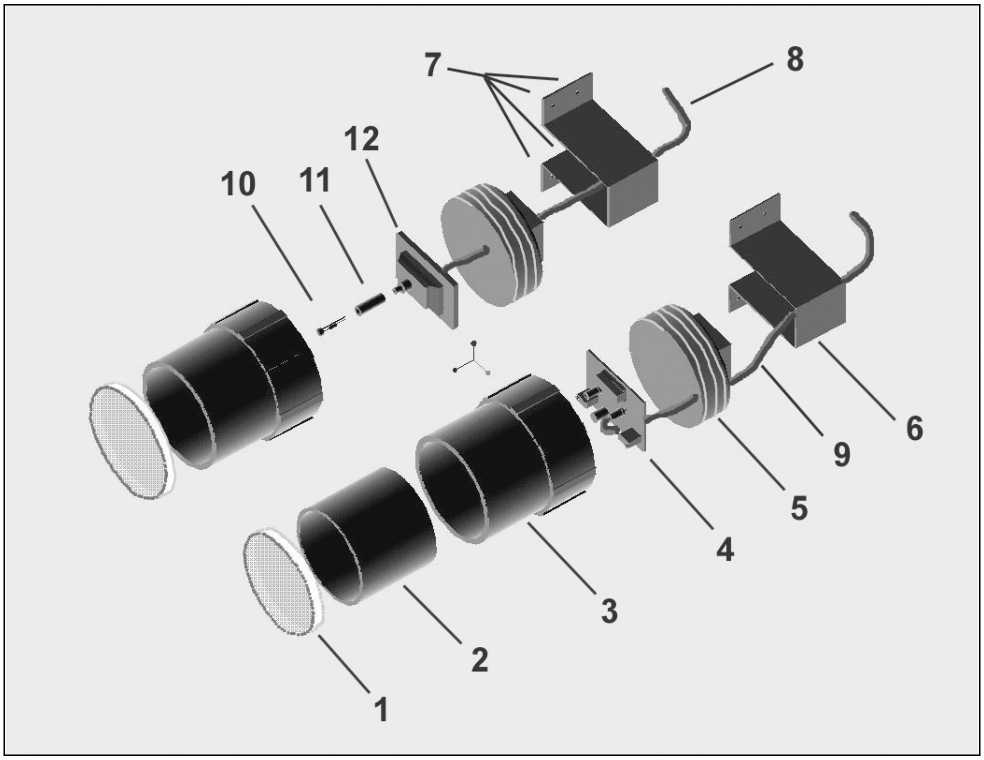

Figure 2. Electronic housing parts (exploded view of Fig. 1C): 1) transparent, scratch-resistant cover made from plexiglas or glass; 2) 3-inch or longer extension tube to shield detectors from sunlight, made from polyvinyl chloride and painted flat black inside to prevent reflection of light; 3) 3-inch-diameter, polyvinyl-chloride, threaded cleanout adapter, also painted flat black inside; 4) infrared detector board; 5) 3-inch-diameter, polyvinyl-chloride, threaded plug; 6) galvanized, deck-post tie to hold square end of threaded plug 5; 7) rivets used to attach unit to the 2-inch angle aluminum mounted on frame; 8) power and ground cable to emitter; 9) power, ground, and data cable to detector board; 10) infrared emitter and resistor; 11) hollow plastic tube to seal emitter (we used part of a ball-point pen); and 12) mounting base with swivel for adjusting alignment of emitter.

circuit is complete while infrared light shines on both phototransistors but is broken when a bat flies through one of the beams. Depending on the sequence of breaks by the two phototransistors, an in-count or an out-count occurs (Fig. 3). When one phototransistor is blocked from receiving infrared light, a sequence of two additional events must occur before the detector generates an electronic pulse.

The array of four infrared lights connects to a circuit board (Appendix I) that delivers power to the detectors and emitters. In addition, this board combines output from the four beams and sends a 1-ms pulse to either of two open channels on a data logger. In this way, each adit has an in- and an out-channel on the data logger. The “combiner board” also prevents beams from interacting with each other. Therefore, each beam acts independently, which means that a count cannot be produced from part of a beam-break sequence on one beam and part of a break sequence on another beam.

For testing purposes, the combiner board has a red and a green light-emitting diode (LED) to indicate when, and in what direction, a beam is broken. For example, running a hand through a beam in one direction triggers the red LED, and in the opposite direction, the green LED. In the field, this allows a simple operational test of each beam without extra electronic equipment. We conduct monthly inspections

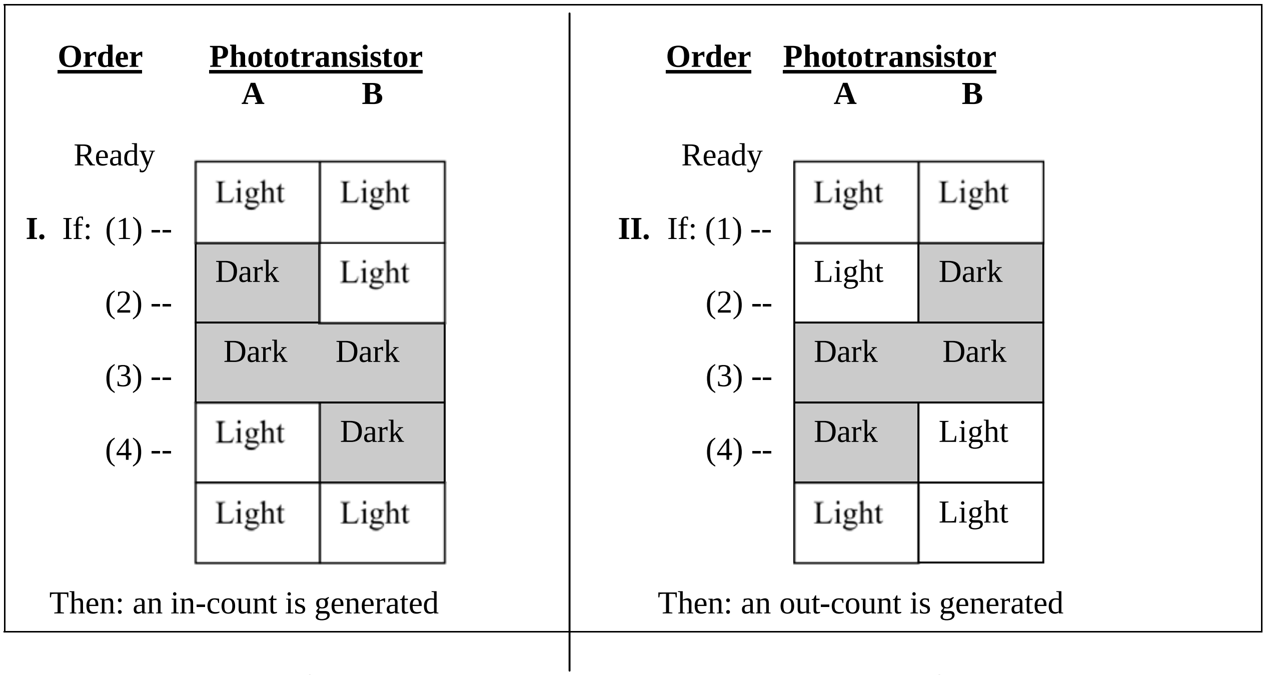

Figure 3. Logic diagram of the directional beam–break detector, showing sequence of events needed to generate an in-count (left) or an out-count (right). Phototransistor A is oriented toward the outside of the mine. When two phototransistors receive infrared light, followed by an ordered break (dark) from an object moving through the beam, a directional in- or out-signal is produced.

during winter and summer, whereas weekly inspections occur during peak periods of activity in spring and fall. Inspections include cleaning the transparent covers over emitters and detectors and hand-testing each beam for directional operation, using the LED indicators. A beam can be adjusted if it is out of alignment, although such adjustments rarely are needed.

For collection and temporary storage of data, we use a data logger (Model CR10, Campbell Scientific, Logan, Utah) that is housed in its own enclosure and located within a utility shed outside the mine. The logger and power supply are connected to the combiner board in each adit by shielded, twisted, 3-pair cable that passes through the mine. We place silica desiccants in the data-logger enclosure and regularly change them, thus preventing moisture from affecting the electronics. Although numerous options are available, we program the logger to tally and record the total number of counts in every 5-min period, as well as every 24 h, to provide two scales for viewing the data. This particular logger has sufficient memory to store data for ca. 5 days, and recorded data may be accessed remotely through a modem installed at the shed or on site by connecting a laptop computer to the storage module.

Our system provides an index to levels of bat activity (Fig. 4), without the observer bias or large commitments of time often required by traditional exit counts. In addition to relative activity, the system can be used to help correlate activity with environmental variables for predicting peak nights of spring emergence (Redell, 2005). Furthermore, the system actually can be used to census a hibernating population, if it is properly calibrated (Redell, 2005).

Calibration

Some bats will fly through the system without breaking any beams or without

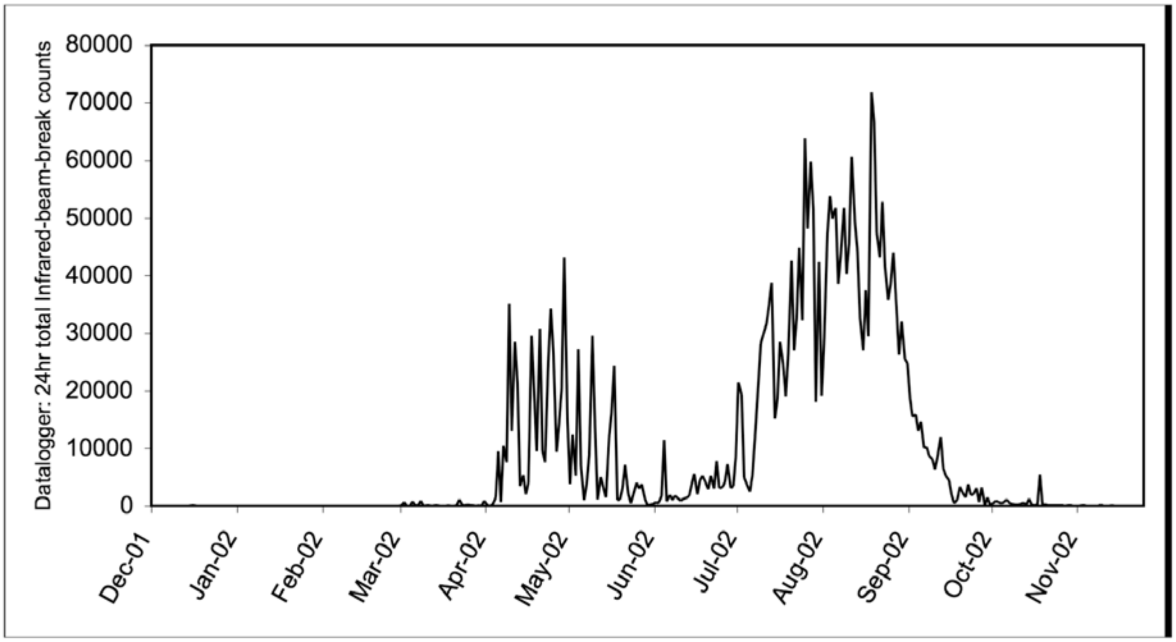

Figure 4. Annual cycle of activity by bats at Neda Mine, Dodge Co., Wisconsin, in 2001–2002. Data are missing for much of February 2002, while the system was being upgraded, but low levels of activity in other winter months reflect the actual situation during hibernation. Each 24-hour datum represents the sum of activity recorded during 288 5-min periods.

producing a complete sequence for a directional count. To determine the relationship between actual bat movement and the number of recorded beam–break counts, we use a video camera with infrared capabilities. Time on the camera is synchronized with that of the data logger and superimposed onto the video recording. By positioning the camera to record a full view of the opening, we can determine how many bats come in and out of a particular adit during a specific period. To calibrate, we record for 5-min periods, on multiple nights, to insure sampling of low, medium, and high levels of bat activity at each adit. Using a video-cassette player and a frame-by-frame dial, all directional movements through the detection window are tallied. We then compare video results (actual bat movement) to the number of counts recorded with the data logger.

After recording the number of bats determined by each method for various 5-min periods, we use the paired data to calculate a regression line (Fig. 5). The slope of the regression line, forced through the origin, is a correction factor for the data logger, and multiplying data-logger counts by the correction factor provides an estimate of the number of bats that actually entered or exited the adit during any 5-min period. These results allow calculation of confidence and predictive intervals, for each estimate of activity over 5 min. Estimates for the accuracy of combined fits, in the form of a net movement, can be done with model building that uses a large part of the data set for creating the model and remaining data to test the model.

Eight regression (calibration) lines were calculated from emergence activity during spring 2001–2002, one for the in- and out-

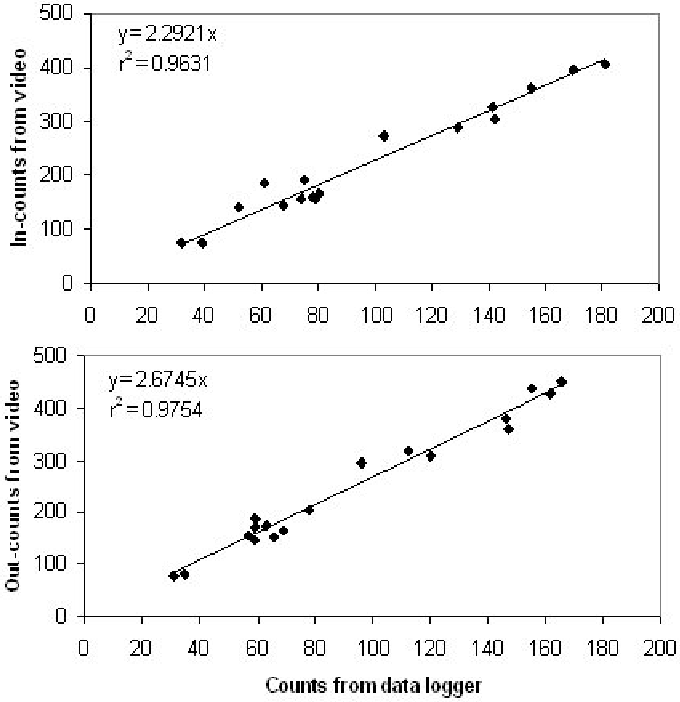

Figure 5. Regression lines for calibration of beam–break detectors at one adit, for bats moving in (top) and out (bottom). The *x*-axis represents the number of in- or out-counts that the data logger recorded, whereas the *y*-axis represents actual number of bats flying in or out, as determined by video analyses. Activity was recorded simultaneously with both methods during 5-min periods.

flight at each of the four adits. Coefficients of regression (r^2) were high and ranged from 0.70 to 0.98. The lowest r^2 was from an adit with low activity and a small sample size, and when we recalibrated the same detectors in the following year using larger sample sizes, the lowest r^2 was 0.87. Although a lower r^2 is associated with larger error terms, a low r^2 will not preclude the ability to obtain an accurate count.

Differences in calibration values (slopes) among and within adits occur due to the specific location of the detector in a particular tunnel, relative to turns, drops, or rises in the adit, which can affect flight behavior. For example, one adit has a setup that allows bats to exit fast and straight, but they usually enter slowly, often with an angled or fluttering flight, as they glide into the chamber below. These differences in flight behavior increase the variability in detection. One way to standardize flight behavior would be to place the detectors between each slot in a bat-compatible gate, where bats have a limited space to move through and are unlikely to pass undetected.

The logic circuit operates within nanoseconds to identify the order of sequential beam-breaks. Once a sequence is completed, the circuit sends a 1-ms pulse to produce an in- or an out-count on the data logger, so the theoretical capacity of the system is 1,000 directional breaks per second. Comparison of the highest counts simultaneously recorded by video camera and the data logger indicates that the system can retain the linear relationship with up to 900 total bats flying through the plane of the four beams in a 5-min period (i.e., 3 bats/sec).

Limitations

Our four-beam system is designed to fit adits at the Neda Mine. Three adits had frames with openings that were 122-cm wide and 76-cm high, whereas the opening at the fourth adit is 152-cm wide and 76-cm high. Taller openings likely would necessitate more than four infrared beams to decrease the possibility of a bat flying through undetected. Although we used a 5°-angle of illumination, wider openings may require an emitter with a narrower angle of illumination or a lens to focus the emitted light to span the longer gap.

Although electronic devices often are useful, measuring activity without the presence of an observer has limitations that must be considered. For example, excessive dirt on transparent covers over the emitters or detectors, broken circuits, and misaligned beams only can be addressed through regular maintenance, whereas errant counts produced by lightning and non-bat detections will be detected only by careful review of raw data. In addition, even though detection systems can distinguish an animal that is exiting from one that is entering, the system can not identify the species of bat. Alternative methods could be used concurrently with these detectors to solve some of the inherent limitations (Thomas and LaVal, 1988).

Acknowledgments

We thank L. Nelson for ideas and assistance; G. Meyer for logistical support; M. Tuttle for advice on calibration; T. Holte and M. Conger for assistance in the field; and T. Melius for producing drawings of the detector. We appreciate K. Crooks, J. Baylis, L. M. Hiltner, and an anonymous reviewer for helpful comments on previous drafts. Funding was provided by the U.S. Fish and Wildlife Service, Wisconsin Department of Natural Resources, Bat Conservation International, Zoological Society of Milwaukee, Max McGraw Wildlife Foundation, University of Wisconsin-Madison Department of Wildlife Ecology, Wisconsin Securities Partners, Chapman Foundation, and the Wisconsin Electric Power Company.

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Appendix I. Technical description of circuits in the bat-detection system

The bat detector consists of four detector boards, corresponding infrared light-emitting diodes, and one combiner board. The current to the emitters and their brightness is controlled by the 220-ohm resistor in series with the 12-V line. The 220-ohm resistance provides sufficient light energy to bias the infrared detectors into their linear region for the given distance. Light from an infrared emitter is aligned with the corresponding detector board to illuminate both infrared detectors.

The detector board consists of a pair of infrared phototransistors connected to a directional latch. Trimmer potentiometers are provided to bias the phototransistors to just below one half of supply voltage. The CD4011, Quad 2 Input NAND gate is configured as a directional latch. When the phototransistors are darkened in the sequence A–AB–B, a 5-µs pulse is produced on the A-B (in) output. When the phototransistors are darkened in the sequence B–BA–A, a 5-µs pulse is produced on the B–A (out) output.

The combiner board consists of a pair of CD4528 dual monostables configured as dual-pulse generators. Outputs from the detector boards are combined using the 1N4148 switching diodes, which are configured as a logical OR gate. A pulse from any detector board will trigger the corresponding CD4528 to produce two pulses. A 250-ms pulse is connected to a LED to produce a visual display, and a 1-ms pulse is produced as the final output for the data count. The 1-ms pulse is routed through the H11D1, high-voltage optocoupler to provide buffering of the pulse before it is sent to the data logger. The 7805 voltage regulator is configured to provide 5 V for the combiner and detector boards. The 1N4007 diode is used as a steering diode to prevent accidental reverse polarity from damaging the electronics.

Figure A1. Schematic drawing for the detector circuit (top) and the combiner circuit (bottom).

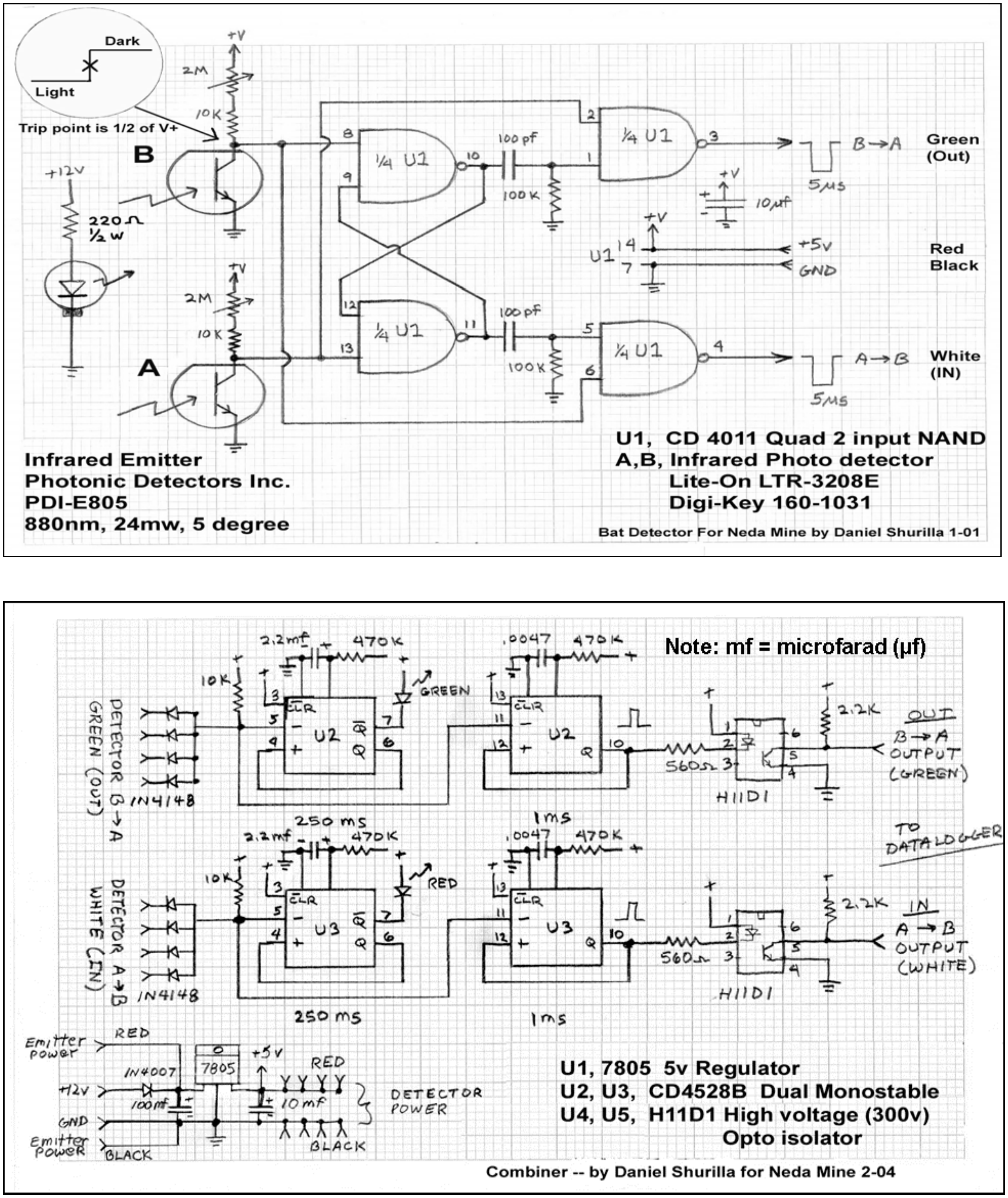

Table A1. List of parts for combiner board and detector board.

Label from Fig. A1	*Description*	**Part number**
A. Combiner board		
U1	7805 5-V regulator	Digi-Key[a] LM340T-5.0
U2, U3	CD4528B dual monostable	Digi-Key CD4528BCN
U4, U5	H11D1 optocoupler	Mouser[b] 512-H11D1
D1	1N4007 diode	Digi-Key 1N4007GICT
D2–D9	1N4148 switching diode	Digi-Key 1N4148DICT
D10	Green LED	Digi-Key P303
D11	Red LED	Digi-Key P300
C1–C2	2.2-µF, 50-V electrolytic capacitor	Digi-Key P5175
C3–C4	0.0047-µF, mylar capacitor	Digi-Key P4559
C5	100-µF, 50-V electrolytic capacitor	Digi-Key P5182
C6	10-µF, 50-V electrolytic capacitor	Digi-Key P5178
R1–R4	470-Kohm, ¼-W resistor	Digi-Key 470KQBK
R5–R6	560-ohm, ¼-W resistor	Digi-Key 560QBK
R7–R8	2.2-Kohm ¼-W resistor	Digi-Key 2.2KQBK
	16-pin IC socket (Qty 2)	Digi-Key AE7216
	6-pin IC socket (Qty 2)	Digi-Key AE7300
	4.5-by-3.5-by-2 inch enclosure	Mouser 563-PN-1323
	PC board	
B. Detector board and infrared emitter		
U1	CD4011 Quad 2 Input NAND Gate	Digi-Key CD4011BE
D1–D2	Infrared photo detector, Lite-On LTR-3208E	Digi-Key 160-1031
D3	Infrared emitter: 880 nm, 24 mW, 5°, Photonic Detectors, Inc.	Digi-Key PDI-E805
C1–C2	0.0001-µF (100-pF) mylar capacitor	Digi-Key P4570
C3	10-µF, 50-V electrolytic capacitor	Digi-Key P5178
R1–R2	2-Mohm, 10-turn trimpot	Digi-Key 3296P-205
R3–R4	10-Kohm, ¼-W resistor	Digi-Key 10KQBK
R5–R6	100-Kohm, ¼-W resistor	Digi-Key 100KQBK
R7	220-ohm, ½-W resistor	Digi-Key 220H
	14-pin IC socket	Digi-Key AE7214
	2 Pos terminal block (Qty 2)	Digi-Key ED1623
	PC board	

[a] Digi-Key Corporation, Thief River Falls, MN

[b] Mouser Electronics, Mansfield, TX.

Abstracts of Papers Presented at the
36^{th} Annual North American Symposium on Bat Research
Wilmington, North Carolina
18-21 October 2006

The following abstracts from the 36th Annual NASBR were compiled, edited, and submitted by Mary Kay Clark, and, except for a few minor formatting changes made by Margaret Griffiths when preparing them for publication, are published here as received.

Abstracts are listed in alphabetical order by first author. Contact information for authors who attended the 36th NASBR can be found in the list of meeting participants that follows the abstracts. Recipients of student awards are indicated by an asterisk (*****) next to the title of the paper.

How Much Do Juvenile Bats Drive Their Mothers To Drink? An Innovative Method for Assessment

Rick A. Adams and Mark Hayes, University of Northern Colorado, Greeley, CO

Data gathered at water holes with the intent of understanding species-specific use patterns have discerned apparent structure and organization associated with resource partitioning and drinking pathways. In this study we present detailed data using a new method for keeping track of visitation patterns of individual bats at water holes. These data give insight into basic, but thus far unanswered, questions such as: How many times per night do bats drink? What is the importance of water resources to reproductive versus nonreproductive females? We captured bats in mist nets near a maternity colony of *Myotis thysanodes* outside of Boulder, CO. Each individual was pit-tagged and released. A flat plate antennae (BioMark, Inc) was placed in a 1-m diameter artificial water hole approximately 0.5 km from tagging sites. Data on humidity and temperature were gathered using a Datascribe, Inc. data logger. A total of 39 adult *M. thysanodes* females were pit-tagged in July and 16 individuals were reacquired with the plate antennae. There was significance difference between numbers of drinking passes for lactating versus nonreproductive females (Nlac = 236, Nnonlac = 15; Kruskal-Wallis, $p = 0.0001$). On average nonreproductive females visited the site 2.4 times nightly (SD = 1.4), whereas lactating females visited an average of 21.4 times nightly (SD = 8.6). An index of temperature and humidity (T/H) was significantly correlated with drinking patterns of nonreproductive ($r = 0.63$, $p = 0.05$), but not with lactating females ($r = 0.51$, $p = 0.13$). Lactating females showed high numbers of drinking passes regardless of temperature and humidity. Drinking bouts were clustered most dominantly right after evening emergence and at dawn.

The Effects of Ecological and Energetic Trade-offs on Innate and Adaptive Immune System Function in the Brazilian Free-tailed Bat (*Tadarida brasiliensis*)

Louise C. Allen, Thomas H. Kunz, Amy S. Turmelle, Mary T. Mendonca, Kristen Navara, and Gary F. McCracken, Boston University, Boston, MA; University of Tennessee, Knoxville, TN; Auburn University, Auburn, AL

Bats have recently and historically been implicated as sources or vectors of important emerging diseases. However, to date few efforts have been made to examine the immune responses in bats and none have been evaluated in an ecological context. The Brazilian free-

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tailed bat (*Tadarida brasiliensis*) possesses a diverse array of characteristics, most notable their gregarious roosting behavior, which provide a challenging topic for immunological research. We examined both innate and adaptive immune responses in this species over one full season at four different roost locations in south-central Texas. We measured bactericidal ability of whole blood from these bats to determine innate immune response, and measured T-cell proliferation in response to mitogenic challenge to determine adaptive immune function. We demonstrate that both arms of the immune system in the Brazilian free-tailed bat are affected by both ecological factors and energy balance in individuals. The competence of the innate immune system appears to rely on the availability of energy and interactions with reproductive activity. Females show a decreased immune response during reproduction, with an increased level of competence at the cessation of lactation. Additionally, non-reproductive males show a higher and more consistent response than reproductively active females. The functioning of the adaptive immune response in this species appears to be associated with roost site differences, possibly attributed to differences in population size, with bats from larger colonies exhibiting more robust immune responses than those from smaller colonies. The data presented support the hypothesis that organisms allocate their limited energy resources to a variety of demands, sometimes at the expense of other functions.

Comparative ecomorphology, flight and echolocation call design in two small aerial hawking bats

M. Reese Arh and John M. Ratcliffe, University of Toronto, ON; Cornell University, Ithaca, NY

In southern Ontario, the entire bat community consists of 5 residential and 3 migratory species, all of which are insectivorous vespertilionids. The residential species are the little brown bat, *Myotis lucifugus,* the northern long-eared bat, *M. septentrionalis*, the small-footed bat, *M. leibii*, the big brown bat, *Eptesicus fuscus,* and the eastern pipistrelle, *Pipistrellus subflavus*. Of these species, *M. leibii* and *P. subflavus* are both the smallest and least studied with respect to hunting behavior. Here we report on flight speed and echolocation behavior from these two bats as they aerially hawked insects in a large, outdoor flight room and describe their ecological morphology. Converse to previous reports, *P. subflavus* has wing loading and overall wing design similar to that of most other *Pipistrellus* species. This species also typically flew at greater speeds than *M. leibii*. One *M. leibii* was observed, and its echolocation calls recorded, while gleaning substrate-borne insects; *P. subflavus* never took insects from surfaces. As predicted from the literature, during search and approach phases of aerial hawking attacks, *M. leibii* produced calls of greater bandwidth, higher peak frequency and shorter duration than did *P. subflavus* when taking airborne prey. We will discuss our results in context of what has been reported for these species while foraging in the wild and thereby elucidate potential competition between, and the ecological niche breadth of, these two small bats as members of this relatively depauperate bat community.

Wing Folding in Bats: Aspects of Morphology and Phylogenetic Interpretation

Maria T. Armour, Nancy B. Simmons, and William A. Schutt, Jr., C. W. Post College of Long Island University, Brookville, NY; American Museum of Natural History, New York, NY

There is great anatomical variation among the over 1,100 extant species of bats and, not surprisingly, there are significant differences in morphology of the wing across taxa. The anatomy, ecomorphology, and function of the wing have been well studied, and it is clear that many aspects of wing morphology are phylogenetically informative. However, little work has been done on patterns of wing folding in bats. We sought to further explore the morphological variation in bat wings with and emphasis on the distal wing elements (i.e., phalanges) and their roles in wing folding. Bats fold their wings for a variety of reasons (e.g., while roosting or during quadrupedal locomotion) and they do so in a variety of ways. We collected data on differences in folding patterns, composition of distal wing elements (bone vs. cartilage), presence/absence of claws or distal expansions on various digits, and number of phalanges in over 150 bat species. Phylogenetic interpretation of our data suggests that observed similarities and differences in these features across bat families are due to a combination of convergence and homology. Regardless, these features appear to offer a useful source of both characters for field identification and phylogenetic analyses, and may have important ecological functions that have yet to be explored.

Patterns of Pre-construction Bat Activity at Proposed Wind Energy Facilities

Edward B. Arnett, David Redell, John P. Hayes, and Manuela Huso, Bat Conservation International, Austin, TX; Wisconsin Department of Natural Resources, WI; Oregon State University, Corvallis, OR

We initiated studies to determine patterns of bat activity and evaluate the use of acoustic monitoring to predict fatality of bats at proposed wind energy facilities in south-central Pennsylvania and south-eastern Wisconsin. Our primary objectives are to 1) determine level and patterns of activity of different species groups of bats using the proposed wind facility prior to and after construction of turbines; 2) correlate bat activity with weather and other environmental variables; and 3) determine if indices of pre-construction bat activity can be used to predict post-construction bat fatalities at proposed wind facilities. We recorded echolocation calls of bats with Anabat II zero-crossing ultrasonic detectors placed at multiple heights on meteorological towers and 22-m tall, portable, telescoping towers from mid-July through October 2005. Bat activity was highly variable throughout the study period, but generally highest from mid-August through mid-September with brief peaks of high activity in October. Bat activity generally was higher just after sunset and declined through the night until just before sunrise the following morning. High (>35 kHz, e.g., *Myotis* species) and low (<35 kHz, e.g., hoary bat) frequency echolocating bats tended to fly at different heights on the study area. Total bat activity increased with increasing temperature and the effect differed at different heights. Bat activity decreased with increasing wind speed and the effect of wind speed was the same for both species groups in both forested and open habitats and at all three heights. We discuss our findings in the context of pre-construction risk assessments and offer suggestions for future monitoring studies.

Site Occupancy Estimations of Forest Bat Species When Probability of Detection is Less Than One

Sybill Amelon, Frank R. Thompson, and Darryl I. MacKenzie, U.S. Forest Service, Columbia, Missouri; Proteus Wildlife Consulting, New Zealand

Declining bat populations continue to be a concern of resource management agencies in North America (N.A.). Conservation and management efforts are hindered by lack of quantitative approaches for drawing inferences about species occurrence over space and time, and for tracking trends in bat populations and distributional patterns, particularly during non-hibernating periods. Few N. A. bat species are so evident that they will always be detected when present regardless of whether detection is by capture or acoustic methods. Nondetection of a species does not imply that the species is absent unless the probability of detection is 1. Recently, maximum likelihood theory has been used to estimate site occupancy when species detection probability is less than one and where it may vary by species and/or habitat. We report results of a long-term project between North Central Research Station and Mark Twain National Forest evaluating site occupancy models using acoustic detection of forest bats as a statistically sound approach for estimating probability of occupancy and detection probability for eight bat species. Using the mark-recapture approach in program PRESENCE and multiple visits to each site, we found probability of detection ranged from 0.34 (*Myotis lucifugus*) to 0.65 (*Lasiurus borealis*). Probability of site occupancy was predicted at appropriate landscape scales for each species based on site and landscape covariates. Our results suggest that this may be a cost effective approach to large scale surveys for eastern forest bat species. A larger scale evaluation in the eastern U. S. is under development.

Bat Migration and Mortality Variation at Wind Farms

Erin F. Baerwald, University of Calgary, Calgary, Alberta, Canada

Wind energy is the fastest growing energy sector in the world. Southern Alberta currently has 14 wind farms with 382 total turbines producing 372 MW, and a number of other projects in various stages of development (>234.5 MW proposed). Between 1 August and 15 September 2005, at Summerview Wind Farm located in flat cropland east of the Rocky Mountains, 532 dead bats were found, an average of 13 bats per turbine. Total estimated mortality was approximately 16/turbine due to scavenger losses (insects). The summer/fall of 2006 has shown a similar pattern, with over 500 carcasses found between 15 July and 15 September. The mortality rate at this particular wind farm is distinctive in the area; most other sites have mortality rates <1 bat/turbine/year. The timing and composition of mortality is comparable with other North American wind farms; the majority of mortalities are migratory tree bats, *Lasionycteris noctivagans* and *Lasiurus cinereus*. Mortality varied from night to night and turbine to turbine. Using acoustic monitoring and carcass searches, I am examining how weather variables such as wind speed and direction, as well as turbine location, affect migration and mortality rate. I conducted daily carcass searches at 10 of the 39 turbines located at Summerview, and weekly searches at the remaining 29 turbines. I used obviously fresh carcasses to correlate mortality rate with weather and location variables. If I can determine correlations between weather and mortality, this will suggest operational means of mitigation. I will experimentally test the effectiveness of such operational measures in 2007.

Aerodynamic importance of variation of wing aspect ratio in bats

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There is substantial diversity among extant bats in wing aspect ratio, and it has been suggested that aspect ratio may be one important determinant of bat flight performance and hence ecological specialization. Much of the theory behind this prediction, however, is based on aircraft aerodynamics. Bats are much smaller and fly at much lower speeds, and hence operate in a Reynolds number regime several orders of magnitude lower than that of human-engineered aircraft. We explore the role of aspect ratio in determining aerodynamic performance at Reynolds numbers typical of bat flight. We constructed model skeletons of bats with outstretched wings based on wing tracings of five species ranging in aspect ratio from near 4 to near 12. The skeletons were fabricated from metal to provide bone-like rigidity. We then constructed wing membranes from compliant latex sheeting similar in thickness to bat wing membranes. Although this sheeting is stiffer than bat wing membrane skin, it approximates skin far better than rigid airfoils. We then tested each model in a low-speed wind tunnel over a wide range of angles of attack. Lift and drag profiles with respect to angle of attack did not differ significantly among wing models despite the large variation in aspect ratio. All wings showed excellent performance at high angles of attack, with a very 'soft' stall around twenty-five degrees but very little loss of lift at angles of attack up to sixty degrees. We propose that the material properties of wing membrane skin may be far more important than wing shape in determining aerodynamic performance.

Day-roosting Habits of Female Fringed Myotis, *Myotis thysanodes*, in Xeric Forests of the Pacific Northwest

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

The importance of tree roosts to the ecology of several forest-dwelling bat species is becoming increasingly clear; however, data remain scarce for the fringed myotis (*Myotis thysanodes*). We radiotracked 25 adult female fringed myotis over 240 roost-days in xeric ponderosa pine (*Pinus ponderosa*) forests on the east side of the Cascade Range in Washington and Oregon 2001-03. Bats used the same roost for 1.8 ± 0.12 consecutive days and moved 0.26 ± 0.10 km between successive roosts. Roosts were 1.4 ± 0.12 km from capture sites and 1.27 ± 0.14 km from the nearest wet stream channel. Ninety-three percent of 118 day-roosts were in rock crevices. Crevice length and crevice width did not differ among rock roosts used by pregnant, lactating, and post-lactating females but lactating (60.9%) and post-lactating (75.0%) females used vertical crevices more often than did pregnant females (41.2%). We often observed adult females roosting solitarily, and occasionally with single pups, in rock crevices. We rarely noted multiple adults and pups in rock crevices in a basalt rock outcrop in Washington and no colony roosts were observed in boulder fields in Oregon. Only six snags were used as roosts, and all were ponderosa pine within a single watershed in Washington. Snags used as roosts were larger, taller, and extended farther above the local canopy than random snags. Flyout counts at snag roosts (n = 17) revealed that bats roosted solitarily most often (64.7%) but colonies of 14, 25, and 118 bats were recorded from two ponderosa pine snags. The significance of snags as roosting habitat for fringed myotis in ponderosa pine forests east of the Cascade Range differs from that reported from forests in more mesic regions.

A Genetic Definition of Species: Implication to Bat Biodiversity

Robert J. Baker and Robert D. Bradley, Texas Tech University, Lubbock, TX

Using DNA sequencing technology and molecular methods, it is now possible and routine to generate a genetic profile for populations and species of mammals. In an overview of data available for mammals, hybridization frequently occurs between genetically well-defined phylogroups, some of which are recognized as species based on morphologic and karyologic data sets. The classical definition “reproductively isolated from each other” is not as accurate as “genetically isolated from each other” for defining mammalian species. Further, genetic data provide greater resolution to units of biodiversity (species), and more accurately identify species boundaries and specimen identification. Because bats are vagile, it might be expected that evolution of genetically isolated phylogroups would occur less frequently than in mammalian groups such as rodents. Preliminary data do not support this. We predict that there will be a substantial number of currently unrecognized species of bats identified by genetic analysis. We discuss alternative definitions and genetic criteria for recognition of species and the implication of their use. Morphological, mitochondrial, and nuclear based datasets are used to identify taxa as species and these datasets are generally thought to be an independent confirmation for each other. If results from a morphological dataset provide statistical support of reciprocal monophyly, the two taxa are accepted as two species. Evidence of reciprocal monophyly from the mitochondrial genome usually is viewed as preliminary and in need of confirmation from one of the other two datasets although the evidence is that such mitochondrial data are probably every bit as valid as morphological data. Requiring statistically supported evidence of monophyly from two of the three datasets would be a substantial elevation of the standard for recognizing species.

Determining Minimum Sampling Effort for Surveys in Eastern and Central South Dakota

Brandon Bales, Scott Pedersen, and Weiming Ke, South Dakota State University, Brookings, SD

Mist netting for bats was conducted along the eastern and western borders of the Missouri River and select tributaries in South Dakota during the 2005 and 2006 field seasons. Nets varied in configuration (e.g., size and height) to obtain the greatest possible capture rate, and were set an hour before dusk then removed before dawn or as conditions dictate. Nets were constantly monitored to reduce the stress incurred by ensnared animals. Unpublished data from 2000 and 2001 field seasons was also included in the analysis. Species accumulation curves were compiled for eight different areas that were areas repeatedly sampled; where sampling effort was cumulatively measured in net-hours. Two asymptotic models (linear dependence model and Clench model) were fit to the resulting species accumulation curves to estimate a range for the minimum sampling effort required to determine total bat species richness for an area within a specified percentage (90%) of the recorded asymptote. The species accumulation models fit well ($0.9759 > r^2 > 0.7681$) for all areas. The predicted lower limit for the minimum amount of effort required to obtain the lower estimate of bat species richness ranged from 31.1 to 284.3 net-hours (N*hr). For the upper estimate of bat species richness, the total amount of effort required ranged from 55 to 3525.3 net-hours (N*hr). This is important due to the prevalence of interest by wind energy companies and developers with regards to wind power in this region.

*Acoustic Mimicry in the Bat-Moth Arms Race

Jesse R. Barber and William E. Conner, Wake Forest University, Winston-Salem, NC

*** Jesse Barber** received the ***Bat Research News*** **Award**

Many moths initiate impressive aerobatic spirals, loops and dives in response to the crescendo of biosonar cries bats deliver as they track their would-be prey. Some moths do more than evade their predators; tiger moths beam a series of ultrasonic clicks from bilateral structures on their thorax (tymbals) back at attacking bats. Laboratory studies support a startle, jamming and/or warning function for these sounds but the only evidence from naïve bats hunting tiger moths on the wing supports an acoustic aposematic function for these sounds. If tiger moths produce sound to advertise the presence of noxious chemicals sequestered in their body tissues, the strategy is open for exploitation by mimicry. Here we test the efficacy of both Batesian and Müllerian mimicry in this acoustic system. Naïve, lab-raised red (*Lasiurus borealis*) and big brown (*Eptesicus fuscus*) bats learned to avoid a model tiger moth over 5 days. On day 6, a second tiger moth species, which produced a different acoustic signal, was introduced to determine if the predators generalize from the first to the second species.

The influence of turbine size on mortality of bats and birds at North American wind farms

Robert M. R. Barclay, Erin F. Baerwald, and Jeffery C. Gruver, University of Calgary, Calgary, AB, Canada

Originally, concerns regarding wildlife at windfarms focused on mortality of birds. More recently, mortality of migratory bats has become an issue at some wind farms. One hypothesis to explain the apparent increase in mortality of migratory bats is the increase in size of wind turbines over the years. Larger diameter rotors may kill more bats per turbine, or taller turbines may extend further into the airspace traveled by migrating bats. To test these hypotheses, we compiled data from published and unpublished reports regarding bat and bird mortality at 30 wind energy sites in North America. When we corrected mortality rates for variation in the rotor-swept-area, mortality of birds did not vary significantly with turbine tower height. However, there was a significant exponential increase in bat mortality per turbine as turbine height increased. Bat mortality was uniformly low at turbines with towers shorter than 60 m. At turbine towers taller than 60 m, some wind farms had high mortalities while others did not. These results reflect the fact that radar studies find migrating birds and bats primarily higher than 100 m above the ground. However, they do not explain why bats are killed at higher rates than birds at tall turbines, or why mortality rate varies among sites with tall turbines. Ongoing studies will hopefully indicate what landscape and temporal variables influence bat mortality and provide potential solutions.

Use of Barns by *Myotis sodalis* and Other Bats in South-Central Iowa

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One barn in southeastern Iowa has been found that contains a large maternity colony of *Myotis sodalis*. To determine if Indiana bats commonly use barns as day roosts in south-central Iowa, we examined barns in six counties during summers of 2005 and 2006. Barns near forests were identified using aerial photos and checked during the day for signs of bat activity. Barns with signs of recent use were then mist-netted and/or harp-trapped at sunset to determine which bats were present. During the two summers, 233 barns were checked during the day; 185 of these (79.4%) showed at least some signs of use by bats. We netted a total of 47 barns and caught 1471 bats. *Eptesicus fuscus* was most numerous (945 individuals; caught in 91.5 % of barns netted), followed by *Myotis lucifugus* (503 individuals; caught in 48.9 % of barns netted), *Myotis septentrionalis* (11 individuals; caught in 17.0 % of barns netted), and *Myotis sodalis* (10 individuals; caught in 12.8 % of barns netted). *Myotis sodalis* apparently does not use barns commonly in this region for day roosts; most individuals caught were entering the buildings at

least one hour after sunset and appeared to use them as night roosts. This possibility warrants further investigation. Barns clearly are an important resource for *Eptesicus fuscus* and *Myotis lucifugus*, both of which commonly form maternity colonies that can be quite large, numbering in the hundreds of individuals. *Myotis septentrionalis* may forage in barns; most individuals were caught flying into the barns shortly after sunset.

Zoogeography and Conservation Status of Bats in the South Pacific and the Hawaiian Islands

Frank J. Bonaccorso, U. S. Geological Survey, Hawaii National Park, HI

The majority of extinctions of vertebrate animals since 1500 AD have occurred on oceanic islands. This review examines the species richness, levels of endemism, conservation status, zoogeography and threats to populations for 148 bat species occurring on islands from New Guinea eastward through the South Pacific and on the Hawaiian Islands. In the region, endemism occurs at the level of family (1), genus (8) and species (101). Based on information from the 2006 IUCN Red List of Threatened Species, extinction has occurred in 3% of the regional species of bats and 22% are listed in threatened and endangered categories. Reflecting on a basic lack of information on populations and natural history, 35% of the species in the region are listed by the IUCN as “data deficient” or “not assessed”. Within the family Pteropodidae, 37% of all regional species are in threatened categories. Pteropodids with body mass over 100 g are most prone to severe population reduction and few of these large species have escaped endangered status. Conservation threats to bats in the region include vulnerability to stochastic events such as volcanic explosions and cyclonic storms, as well as predation by humans for bush meat, disturbance to roosts, potential rise in sea level, and loss and fragmentation of forests. Using New Guinea as an example, bat species richness rapidly declines as elevation increases. Additional protected reserves located in lowland forests are crucial for the preservation of the rich bat diversity on the islands of the South Pacific.

Arboricultural Climbing Techniques Provide Safe and Efficient Access to Tree Cavity Roosts

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To study forest roosting bats, it is necessary to access roosts in trees. Climbing to *Eptesicus fuscus* cavity roosts in aspen trees in Cypress Hills, SK is difficult because roosts can be as high as 20 m and are often dead or decayed. Many biologists learn to climb themselves using limited amounts of safety and fall protection equipment. This is dangerous, especially if trees are in mid-late stages of decay and have presence of fruiting bodies and fungus growths on the trunk. Professional tree climbing is a high risk occupation, with falls accounting for as many as one third of all tree-climbing fatalities. Thus, we contacted a certified arborist to train us to ascend to cavities. Using arboricultural climbing techniques and equipment used by professional arborists, we learned to climb trees safely by first testing the stability of the tree and then by ascending and descending a rope and not the tree itself. We used these techniques for a variety of applications including trapping bats emerging from the roost, taking cavity measurements, and recovering shed transmitters. Another advantage to the climbing techniques and equipment used by professional arborists is that it is less damaging to the tree, which allows for a potential increase

in the feasibility and safety of conducting forest bat roost studies and monitoring forest bat populations over the long-term.

Effects of Calcium Intake on Reproductive Output in Big Brown Bats (*Eptesicus fuscus*)

Christina M. Booher, Indiana State University, Terre Haute, IN

Calcium is an essential nutrient for mammalian reproduction. Calcium deficient diets may lead to reductions in litter size, neonate mass, neonate size, or relative size of neonate to mother. Insects commonly consumed by North American bats generally contain an insufficient amount of calcium to meet estimated daily requirements, especially during pregnancy. Increasing dietary calcium might therefore increase one or more of the above mentioned reproductive factors. To test this, twenty pregnant big brown bats (E. fuscus) were captured from a maternity colony in Indiana and maintained in captivity for the duration of their pregnancy. Bats were hand-fed a food mixture containing either the amount of calcium estimated to be ingested in the wild or an amount that fulfilled an estimated daily requirement for this species. Subsequent offspring were counted, weighed and forearm length was measured, and these measurements were compared between the two experimental groups. Increasing dietary calcium appeared to have no significant morphometric effects on neonates between groups, however it did affect the extent to which maternal size influenced total offspring mass. This suggests that calcium deficiency does impose some limit on reproductive output, and that calcium mediates the effect of maternal mass on litter mass.

A Reanalysis of Apparent Survival Rates of Indiana Myotis (*Myotis sodalis*)

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The estimation of demographic rates is important for conservation and management of species. However, with the exception of an estimate for adult survival by Humphrey and Cope in 1977, there are no estimates of any demographic rates for the endangered Indiana myotis (*Myotis sodalis*). Their estimate, while the best available, is based on techniques that have been replaced by newer, more flexible, and less biased techniques. Therefore, we reanalyzed a subset of the data first analyzed by Humphrey and Cope using a Cormack-Jolly-Seber model. Two models (φ(year) p(sex*year) and φ(year) p(sex*year)) are equally parsimonious, so we used model averaging to estimate apparent survival. We used this estimate to calculate the average cumulative survival each year after banding for four un-aged cohorts. Our estimate suggests that apparent survival is considerably higher than estimated by Humphrey and Cope the first year after banding and lower the second year after banding. Subsequent to the first 2 years after banding, our estimates are similar, but slightly lower than those reported by Humphrey and Cope. These results, while useful, cannot be taken as true survival rates for Indiana myotis because of limitations in the data and we suggest this estimate be used appropriately when making management decisions. We will discuss limitations in this type of data and make suggestions for experimental design of future studies to collect data more appropriate for estimation of demographic rates in bats.

A Portable, Low-maintenance System to Film Nightly Activity at a Roost Tree for Under US$1800

Rachel B. Bricklin and Allen Kurta, Eastern Michigan University, Ypsilanti, MI

The evening bat (*Nycticeius humeralis*) is at the northern edge of its range in southern Michigan, and little is known about its nightly activity at a roost tree during the breeding season. However, as with many nocturnal mammals, behavioral observations in the field can be difficult. To address this problem, we developed a system to film in the dark throughout the night. This filming system is similar to that described by Rodrigues and Palmeirim (BRN 35: 77-79) in that it combines infrared lights, an infrared-sensitive camera, and a recorder, but the real strength of our system is the recorder. We used a 100 GB digital video recorder with a battery life of >14 hours and an LCD screen that is small and lightweight. The entire recorder weighs <0.5 kg, including battery. When combined with a Lotek data logger that indicated the presence of a signal from a bat carrying a radio transmitter, this system was able to visually confirm that a bat was near the roost opening and document its behavior. We are using this system to study usage of day roosts at night by evening bats, but this system could be used to film other species as well throughout the day or night.

Another Feathered Bat Story: Evidence for the Importance of Individual Variation

R. Mark Brigham, Andrew E. McKechnie, Murray B. Christian and Robert A. M. Ashdown, University of Regina, Regina, SK; APES Wits, Johannesburg, South Africa; Environmental Sciences UKZN, Durban, South Africa

There is considerable recent evidence that individual differences in bat behavior e.g., association patterns in Fission-Fusion roosting systems and echolocation e.g., variation in call structure, are important. As part of a study on Freckled Nightjars (*Caprimulgus tristigma*), we found evidence for individual variation in the expression of torpor patterns. This leads us to encourage more emphasis on this in studies of bats. Based on similarities in body size, foraging style, a sedentary nature, arid habitat use, and exposure to sunny albeit cold winter days, we predicted that Freckled Nightjars would employ seasonal torpor (behavioral hibernation) akin to Common Poorwills in North America. We recorded skin temperature (Tsk) of 6 radio-tagged individuals roosting within 5 km of each other in the 4200-ha Kgaswane Nature Reserve near Rustenburg, SA during July 2006. Individuals exhibited a range of physiological responses to low insect abundance and cold temperatures. One individual entered torpor every day with minimum Tsk dropping to 10º C on some occasions while another individual never entered torpor. Torpor bouts typically occurred between midnight and dawn and again after arousal for several hours after dawn. Gender, roost aspect, and body condition when captured, did not account for the differences. Above average rainfall the previous summer likely resulted in higher than normal insect abundance however the reason(s) for variable physiological responses by the birds remains unknown. Given the recent interest in torpor use and hibernation by bats, our results prompt us to encourage attempts to assess the nature of and rationale for variation in torpor expression between individuals.

Sexual Segregation and Community Composition: A Seasonal Perspective on the Bats of the Chisos Mountains, Big Bend National Park

Carson M. Brown and Loren K. Ammerman, Angelo State University, San Angelo, TX

Big Bend National Park (BBNP) has been surveyed extensively for bats. However, the majority of netting efforts have focused on the lowlands. The upper drainages (1770 to 2190 m) of the Chisos Mountains host a biotic community that is unique to BBNP. Referred to as the Moist Chisos Woodlands (MCW), this habitat is typified by an Arizona cypress/pine/oak association. Using traditional mist netting methods, the MCW habitat was surveyed for bats in spring, summer, and autumn. Inconsistent with accepted trends, this high elevation bat community was more species rich than communities of the surrounding lowlands. Consistent with other high elevation surveys, a strong male bias was observed. For nine of the thirteen species recorded, > 70% of all captures were male. For five of those nine species, only males were captured: *Antrozous pallidus* (n = 58), *Myotis thysanodes* (n = 37), and *Tadarida brasiliensis* (n = 17), *Myotis yumanensis* (n = 4), and *Lasionycteris noctivagans* (n = 1). Interestingly, *Mormoops megalophylla*, which was absent in spring, was the second most abundant species in summer. Further, all *M. megalophylla* captured were females, the majority of which were lactating. Understanding the occurrence of reproductive female *M. megalophylla* at high elevations may provide insight into the understanding of sexual segregation in bats. Lastly, there were notable species specific changes in relative abundance and sex ratios, with an overall decrease in bats captured, from spring to summer. These seasonal changes in community structure demonstrate the importance of multi-season surveys in obtaining more complete demographic data, and ultimately, understanding the community ecology of bats.

A Comparison of Bat-use between Native Cottonwood Galleries and Non-native Saltcedar Groves near Winkelman, Arizona

Debbie C. Buecher and Ronnie Sidner, University of Arizona, Tucson, AZ; Ecological Consulting, Tucson, AZ

Recent discussions in the literature and at professional meetings describe impacts that exotic plants (particularly saltcedar – *Tamarisk* spp.) in the West have on native riparian species. Data suggest that some bird species, particularly the endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*), will use tamarisk groves for foraging and nesting. Because these findings may impact land managers' plans to remove non-natives, it is imperative that we understand how exotic plants impact the suite of species that use riparian corridors. In the summer of 2005 we conducted a preliminary study to evaluate and compare bat-use of monotypic saltcedar groves vs. native cottonwood galleries near Winkelman, Arizona. Taking advantage of insectivorous bat biosonar, we compared foraging activity by bats each month for four months in the two habitats using Anabat II (frequency division) ultrasonic bat detectors. We also conducted limited active acoustic sampling using Pettersson D240x (time expansion) detectors coordinated with Anabat detectors using AnaPocket software. We evaluated bat-use as the number of feeding buzzes in the two habitats and we also investigated bat-use as the average numbers of foraging calls in each of the two habitats. Our results suggest that activity levels by bats may be greater in native cottonwood galleries; however we conducted additional monitoring during summer 2006 to better understand differences observed during the initial study. Because invasive plant species, such as saltcedar, influence historic biotic community structure, it is

critical that we understand how native taxa use riparian corridors in order to evaluate the impact of non-native plants and animals.

EARS: Software for automated analysis of broadband digital recordings

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With the availability of equipment capable of digitizing ultrasonic signals, researchers are faced with a dilemma. Bats can produce so many signals in a brief time that the number of calls is too large for manual analysis. Automated, computerized analysis of these calls is a promising possibility, as there are clear advantages to such a technique. Automated analysis is conceptually simple, but it presents some practical difficulties, many of which relate to the fact that a computer lacks the ability to distinguish patterns as easily as the human eye. In addition, the conditions during the recording can affect the quality of the sounds and the resulting analysis. Finally, given the variability in bat sonar signals, it is unlikely that a single program will be capable of analyzing all the echolocation signals that bats produce. We describe a set of analysis routines that were written in Matlab to analyze broadband echolocation calls of durations less than 50 milliseconds. These routines measure and record variables that describe the time, frequency, and amplitude structure of the signals. We discuss the problems that arose in developing those routines and the solutions we have implemented. These programs are part of a suite called EARS (Echolocation Analysis and Recording Software) available to researchers on an open-source basis. The software allows users to adjust a number of parameters, permitting the analysis to encompass different needs. Users with access to Matlab can modify the source code and routines can be compiled to produce software that can be run on computers that do not have Matlab installed. We hope that EARS will grow through the addition of new routines by interested users.

Results of a Re-survey of *Corynorhinus rafinesquii* roosts, including the first Documented Hibernacula in Southeastern Virginia

Ela S. Carpenter and Stephanie Rollins, Christopher Newport University, Newport News, VA

Little is known about the roosting ecology of *C. rafinesquii* in Virginia (the northern boundary of its range). As part of a study to quantify roosting and habitat associations of this species we conducted roost surveys throughout southeastern Virginia. These surveys included structures identified by the Virginia Department of Game and Inland Fisheries as *C. rafinesquii* roosts in 2001. Because all structures of interest were on private land, we contacted landowners to obtain permission to visit the sites. After obtaining written or oral permission, we visited a total of thirteen sites to evaluate current use. Of the thirty landowners contacted, nine gave us permission to visit their properties. We discovered that several structures documented as roosts in 2001 are now collapsed and no longer available to bats. Of the remainder, four continued to be used by the species while we failed to detect recent use at six sites. While we found two previously undocumented roosts, three of the five structures housing maternity roosts during the 2001 surveys have been destroyed. In addition to surveying sites for use and quantifying occupancy, we installed data loggers throughout structures to evaluate climatic associations of roosting bats. We found three solitary hibernating *C. rafinesquii* that were in a variety of structures. We believe these represent the first documented hibernacula for this species in

Virginia. In this presentation, I will discuss specific roosting associations, seasonality of roost use, and implications of this study for the effective management of *C. rafinesquii* in Virginia.

Antiphonal calling behavior in adult white-winged vampire bats (*Diaemus youngi*)

Gerald Carter, University of Western Ontario, London, ON, Canada

In many social birds and mammals, temporally precise and alternating vocal exchanges (i.e. antiphonal calling) mediate social interactions. In bats, antiphonal calling is known to occur between mothers and pups, but less work documents active vocal exchanges between adults. Temporally associated bouts of social calls commonly occur amongst unrelated adult white-winged vampire bats (*Diaemus youngi*), and I hypothesized that these bouts represent antiphonal calling. Using 17 captive *D. youngi*, I tested four hypotheses explaining temporally associated calling. First, I investigated whether mutual calling is a response to conspecifics or simply to a shared stimulus. Second, to determine whether bats were responding specifically to social calls and not simply the presence of conspecifics, I measured vocal response to high-speed playback of social calls versus echolocation pulses from the same sender in a paired design for same sex roostmates, same sex non-roostmates, and different sex non-roostmates. Third, I used these playback data to determine whether bats attempted to 'match' playback calls, i.e. respond vocally with temporal precision. Fourth, I investigated inter-individual variation to see if acoustic cues can provide individual signatures. Playback experiments followed a 'blind observer' protocol. All 17 adult bats emitted social calls in response to live conspecific calling, even when spatially isolated from other stimuli. Bats responded more to playbacks of social calls than to echolocation calls. Furthermore, vocal responses occurred more often within 500 ms of a preceding call playback than expected by chance alone based on an individual’s overall calling rate for a trial. Results of inter-individual signatures are forthcoming. These preliminary findings provide evidence that bats emit social calls in the form of active vocal exchanges, and suggest a contact call function.

Converting Abandoned Mines to Suitable Hibernacula for Endangered Indiana Bats (*Myotis sodalis*)

Timothy C. Carter, Bradley J. Steffen, and George A. Feldhamer, Ball State University, Muncie IN; Southern Illinois University, Carbondale IL

Entrances to abandoned mines are often left to collapse, or are intentionally sealed for safety and liability reasons. In Southern Illinois, there are numerous abandoned microcrystalline silica mines owned by Unimin Specialty Minerals. In the last decade, they have expressed interest in preserving those mines currently used by bats. After an extensive survey of the mines, several were identified as having low current bat use but high potential for use by significant numbers of bats. In 2003, we began to examine the microhabitat characteristics of all the mines with the goal of identifying important characteristics for bats. In late summer 2004, those data were used to direct physical modifications of one large mine with low bat use to increase numbers of hibernating bats. Bat use that winter (2004/2005) increased from <500 to approximately 1400. Counts of hibernating bats for 2005/2006 increased an additional 25% to approximately 1900 individuals, including Indiana bats (*Myotis sodalis*). The conversion of this mine to habitat suitable for hibernating bats is similar to work done in caves that have been restored to re-establish historic bat use. However, historically the Unimin mines never had high bat use nor were they intended to house bats. Thus, this work has created suitable habitat for hibernacula. Currently, about 50,000 bats, including approximately 36,000 Indiana bats, hibernate within this system of mines. Opportunities exist to modify as many as 5 more large mines to create additional suitable hibernacula.

Movement Areas for Spotted Bats (*Euderma maculatum*), Northern Arizona

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Little information exists describing the movement or foraging patterns of spotted bats. We attached radio transmitters to 7 spotted bats (*Euderma maculatum*) captured over ponds in Great Basin desert scrub vegetation type, June 2005. We radiotracked bats for 7 days to identify movement areas and travel corridors in a ~1000-km^2 landscape in northern Arizona. We used Programs Locate II and CalHome to estimate movement areas for each bat. Bats foraged primarily in Great Basin desert scrub and pinyon-juniper vegetation ≤25 km from roosts. On most nights, bat emerged at approximately 30 min after sunset, foraged until ~23:30, night-roosted for 1 to 3 hrs, then returned to day roosts between 03:00 and 04:00. Movement areas (95% contour) were estimated as 35,150 to 122,900 km^2 using locations (n = 8 to 25 for each bat) with ≤20 km^2 error polygons. Bats regularly used canyons and washes to access potential foraging sites. For example, on 4 successive nights, 12 to 61 spotted bats passed through 1 canyon between ~20:45 and 21:30. It did not appear that spotted bats maintained exclusive movement locations during the project, although they may have partitioned habitat temporally. We saw bats change movement areas, possible evidence of bats tracking changing prey availability. Spotted bats appeared to be patchily distributed but locally common in northern Arizona. Spotted bats used similar habitat compared to other populations; foraging distances that we documented remained much greater than from other locations in western North America.

*Behavioral Adaptation to Group Foraging in *Eptesicus fuscus*

Chen Chiu, Wei Xian and Cynthia F. Moss, University of Maryland, College Park, MD

*** Chen Chiu** received the **Speleobooks Award**

Echolocating bats commonly face the challenge of avoiding acoustic interference from conspecifics. Artificial signals which resemble a bat's own echolocation calls affect its distance discrimination in psychophysical experiments. Therefore, it is important for one bat to avoid interference with another bat's echolocation calls when flying and foraging with conspecifics. Previous jamming avoidance studies on echolocating bats have reported spectral and temporal changes on call structure when one bat encountered its conspecifics in the wild. The purpose of this study is to examine whether *Eptesicus fuscus* adjust their echolocation calls to avoid interfering with each other in the laboratory, where the conditions can be carefully controlled and flight, as well as vocal behavior, can be monitored when a pair of bats pursue a single prey item. A total of three *E. fuscus* (two males and one female) were successfully trained to catch a tethered mealworm in a large flight room. Baseline data were taken first when each bat intercepted prey while flying alone. Two bats were subsequently flown together with a single prey item. Preliminary results reveal that paired bats adjust either their relative positions or the echolocation call designs to avoid jamming each other's signals. "Tandem flight" is common in the two-bat scenario and the trailing bat tended to stop vocalizing when the distance between two individuals was small. This study provides insight into the adaptive behaviors in *E. fuscus* for successful echolocation in a complex acoustic environment.

DNA Barcoding Bats: Projects Patterns and Prospects

Elizabeth L. Clare and Paul D.N. Hebert, University of Guelph, Guelph, Ontario, Canada

A pilot project focusing on bats has been undertaken as part of a large-scale research initiative examining the patterns of sequence diversity in a standardized region of the cytochrome c oxidase subunit 1 gene (COI) in all animal life. The main goal of this project is the development of a species-level identification tool, as part of the international Barcode of Life initiative. The dataset on bats comprises nearly 4000 barcode sequences from over 350 species representing 14 families from diverse geographic locations, with an emphasis on the Neotropical, Indomalayan and Holarctic regions. The initiative includes research projects carried out in conjunction with experts on chiropteran taxonomy from several institutions worldwide. In this presentation, I discuss results of DNA collection, DNA barcode resolution of alpha-level taxonomy and zoogeographic patterns of genetic diversity. I also compare the performance of COI and cytochrome b for these purposes. Finally, I examine the results of a detailed investigation of DNA barcode variation in 87 species of bats from Guyana. Ninety-three percent of these species showed low intraspecific variation (mean = 0.60%), and clear sequence divergence from their congeners (mean = 7.80%). The remaining 7% show intraspecific lineages with up to 14% COI sequence divergence between them suggesting overlooked species. By contrast, analyses of 175 morphospecies of Southeast Asian bats suggest that diversity in this region may be underestimated by 20%. The present study supports the effectiveness of DNA barcoding as a tool for the identification of regional bat assemblages, even within highly diverse tropical faunas and justifies further expansion of its taxonomic and geographic coverage.

A review of Artificial Roost Structure Design for Rafinesque's Big-eared Bat, *Corynorhinus rafinesqui*

Mary K. Clark, NC Wildlife Resources Commission, Raleigh, NC

Loss of both natural and anthropogenic roosts for Rafinesque's big-eared bat *(Corynorhinus rafinesquii)* is occurring throughout its range. The species is of federal concern and it is also listed in some category of concern (ranging from state endangered to special concern) by each state in its range. Natural roosts for this species include caves and the extensive cavities that occur only in large old trees. Generally, the roosts that are most well-known, and monitored throughout the range, are in abandoned buildings. These sites are rapidly being lost, primarily to natural deterioration and land-use conflicts. Additionally, recent documentation of the loss of natural summer roosts for this species has been documented in Mississippi and North Carolina. In Mississippi a number of trees with cavities used by this species on the DeSoto National Forest were blow-down during Hurricane Katrina. Concern for the population in this area led to a cooperative venture between two non-profit organizations (the Southeastern Bat Diversity Network, and Defenders of Wildlife) and the USDA Forest Service to provide alternative structures for the affected colonies. To ensure that funds were used to best effect a review of roost designs was conducted to assess the success of various structures. Several states have extensive roost restoration or mitigation projects, however, monitoring for bat use is irregular, and the lack of data on roost characteristics (e.g., temperature) and the differences in designs makes it difficult to assess the success of these projects. Rangewide coordination to standardize monitoring protocols and to study and improve designs are needed for more effective conservation efforts for this species.

Bacterial Fauna of Bats in West Virginia

Phillip Clem, Daniel Judy, Jamie Totten, Kirsten Mauro, Amanda Starcher, and Sara Clark, Univeristy of Charleston, Charleston, WV; Indiana State University, Terre Haute, IN

A total of 328 bacterial colonies were isolated from 7 species of bats (*Lasiurus borealis, Lasiurus cinereus, Pipistrellus subflavus, Eptesicus fuscus, Myotis lucifugus, Myotis septentrionalis,* and *Lasionycteris noctivigans*) in West Virginia during the summers of 2000 and 2001. Fifty-one different kinds of bacteria were identified. Of these, 35 were from fecal samples, 19 were from saliva samples, and 18 were from genital/skin samples. More different species of bacteria were found in the fecal samples (36) than in either saliva (20) or skin (19). Thirty-six of the fifty-two bacterial species were found in a single sample location (feces, saliva, or genital/skin) in all bats collected. The most common species of bacteria found were *Serratia liquefaciens* and *Serratia marcescens*). These two bacteria were found in all three sample locations and in six of the seven species of bats. Three other species of bacteria were found in all three sample locations (*Rahnella aquatilis, Enterococcus flavescens,* and *Enterococcus gallinarum*). *Rahnella* was found of 5 of the 7 species of bats while the two *Enterococci* were found in three of the bat species. *Lasionycteris noctivigans* harbored 27 different kinds of bacteria, *Lasiurus borealis* 20 and *Myotis septentrionalis* 19. *Lasiurus cinereus* had only 3 kinds of bacteria.

Fully Automated Identification of Three Bat Species: *Lasiurus borealis, Nycticeius humeralis,* and *Pipistrellus subflavus* Using Full-Spectrum Acoustic Data

Aaron J. Corcoran and Joseph M. Szewczak, Humboldt State University, Arcata, CA

Bat biologists have primarily classified echolocation calls to species either qualitatively by expert identification or quantitatively by manually extracting call parameters that are then run through classification algorithms such as discriminant function analysis (DFA). Qualitative identification has received criticism for its lack of repeatability and for varying classification rates depending on user experience. Human-interfaced quantitative identification is generally more repeatable; however some variability still exists in how users extract call parameters. Both methods can be costly and time-consuming, especially with the proliferation of continuously recording acoustic monitoring. We have developed a fully automated system for locating, parameterizing, and classifying echolocation calls and tested it on three sympatric bat species having similar call characteristics: *Lasiurus borealis*, *Nycticeius humeralis*, and *Pipistrellus subflavus*. We extracted 16 parameters from time, frequency, and amplitude domains both manually and automatically from 1,194 echolocation calls of 210 sequences. We randomly assigned all sequences to three groups and used each group to test the accuracy of DFAs created from all sequences exclusive to that group. Each sequence was labeled as the species predicted by that of the majority of calls within that sequence. Manual classification determined 13 of 210 sequences as ambiguous and correctly classified of 83.8 % of the remaining 197 sequences. Automated classification determined 12 of 210 sequences as ambiguous and correctly classified

87.8 % of the remaining 198 sequences. These results indicate fully automated systems can classify echolocation calls as well or better than human-moderated systems at dramatically reduced time, cost, and with a minimal requirement for user training. Additional evaluation parameters will likely increase the overall rate of correct identification.

Effects of Sample Size on Habitat Modeling for Forest-Roosting Bats

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

Research on forest-roosting bats has increased in the past 20-30 years. However, sample size necessary to detect biologically significant differences in use of forest habitat is unclear. The objective of this study was to provide a quantitative comparison of the effect that sample size of bats has on the performance and ranking of habitat models. We performed logistic regression on variable sets proposed by Kalcounis-Rüppel et al. (2005) and Lacki and Baker (2003) as biologically meaningful to forest-roosting bats. In addition, two other models were constructed for comparative purposes. Models were built for sample sizes of 5, 20, and 48 radio-tracked bats and compared among sample sizes. For the sample sizes of 5, 20, and 48 bats, the percent of correctly placed roost trees averaged 2.8 (SD = 3.2), 50.4 (SD = 2.8), and 83.2% (SD = 4.6) for each sample size, respectively. The direction of the measured characteristics from random or available trees varied among sample sizes. Model separation increased using the corrected Akaike Information Criterion (AICC) differences for the sample sizes of n = 5 (range = 0.0 – 3.8), n = 20 (range = 0.0 – 7.6), and n = 48 (range = 0.0 – 23.0). The predictive capabilities of all models increased markedly when the sample size of bats increased from n = 5 to n = 20. Variable loadings were affected by sample size; however, loadings for variables were similar for n = 20 and n = 48. AICC model ranks were comparable for the sample sizes of n = 20 and n = 48. The recommendation from this study is that a minimum sample size of 20 bats per species should be achieved when studying roost selection of forest-roosting bats.

Epidemic Models of Bat Rabies with Permanent and Temporary Immunity

Dobromir T. Dimitrov and Thomas G. Hallam, University of Tennessee, Knoxville, TN

Bats have been recognized as natural reservoirs of rabies virus, which frequently resurge into human populations or domestic livestock. Recent field samples from Brazilian free-tailed bats (*Tadarida brasiliensis mexicana*) colonies in south Texas exhibit high seropositivity levels of over 40% as indicated by presence of antibodies in blood serum, while viral RNA is found only in less than 2.5% of salivary swabs indicators. We developed epidemic models of bat rabies to investigate what makes it possible for rabies to persist into bat populations. Our modeling approach is based on widely accepted hypothesis that successful viral transmissions result in two distinct pathways, infection, which implies development of the disease, period of infectivity and death, or exposure, which implies survival with partial immunity, without development of rabies. Passive carrier stage is excluded as viable explanation of viral persistence into bat colonies. We present a complete mathematical analysis of proposed epidemic models and describe what parameter conditions support the experimental data. We also investigate how the duration of the acquired immunity (infinite or finite) affects the disease dynamics.

Occurrence of Prey and Diet of the Ozark Big-Eared Bat (*Corynorhinus townsendii ingens*)

Luke E. Dodd and Michael J. Lacki, University of Kentucky, Lexington, KY

Moths are the primary prey of *Corynorhinus*, but it is unclear how this prey base varies over the landscape. Further, prey of the Ozark big-eared bat (*C. townsendii ingens*) are unknown beyond the ordinal level. We investigated moth occurrence around roosts of this endangered bat and examined its diet. In 2005, moths were sampled around roosts using light traps in habitats in both rural-fragmented and forested landscapes in the Ozark Mountains. Moths were identified and enumerated; habitat selection was then analyzed for common families ($n > 100$ specimens) in each landscape. Edge habitat was generally avoided in the fragmented landscape, and moth occurrence in riparian and upland forest varied among families ($P < 0.01$). In the forested landscape, moths were found in larger size-classes of timber; sapling timber was generally avoided ($P < 0.01$). Moth wings discarded by Ozark big-eared bats while feeding were collected from roosts to assess prey consumption; 269 wings were identifiable, representing 53 species within 8 families. Noctuidae and Notodontidae were eaten in both landscapes, but consumption of other taxa varied. Geometridae and, to lesser extent, Arctiidae were eaten in the fragmented landscape, but generally not in the forested landscape. In contrast, Sphingidae were a substantial portion of the diet in the forested landscape, but were not eaten in fragmented landscape. Consumption by the Ozark big-eared bat mirrors that of other *Corynorhinus* in eastern North America, but our data suggest that consumption patterns varied with differences in land use or habitat availability between landscapes. Our study documents taxa previously unrecorded as prey of *Corynorhinus*, stressing the need for fuller understanding of the foraging of *Corynorhinus* throughout North America.

Winter Energetics of the Endangered Indiana Bat

Christin Dzurick and Tom Tomasi, Missouri State University, Springfield, MO

Indiana bat (*Myotis sodalis*) populations continue to decline despite current conservation efforts. Recently, the effects of climate and microclimate on the hibernation of this species have come into focus. As hibernacula temperatures in caves have increased, the metabolic rate of hibernating bats should increase, resulting in faster utilization of the bats' stored energy reserves; bats use more energy to maintain their torpid state at higher temperatures and arousals may occur more frequently. This increase in metabolism sacrifices energy reserves and if reserves 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) will contribute to conservation efforts of this endangered species. We quantified energy budgets of Indiana bats at several ambient temperatures to determine the optimal hibernation temperature (i.e., with the greatest amount of energy savings). Bats were housed in an environmental chamber that mimicked cave conditions of 4 - 6^{o}C and 77+% humidity. Arousal patterns were determined at 3, 5, 7, and 9^{o}C by the use of iBBat data-loggers. Oxygen consumption rates of torpid bats at 1, 3, 5, 7, and 9^{o}C were measured in metabolic chambers. The metabolic cost of arousals at each temperature was also determined. Arousals occurred more frequently at higher temperatures. Metabolic rates during torpor declined with decreasing temperature to 5^{o}C, then increased to 1^{o}C. It was concluded that bats hibernating at higher temperatures (above 5^{o}C) are more likely to deplete energy reserves prior to the end of the hibernation season. Successful hibernation of Indiana bats could be enhanced with hibernacula that are maintained at the temperatures with the lowest energetic needs.

Patterns of Roost Use of Abandoned Mines in Death Valley, California

R. East, M. Slosser, M. Rauschkolb, and R. E. Sherwin, Christopher Newport University, Newport News, VA; Rio Tinto Minerals, Centennial, CO

The effective management of abandoned mines for bats is often complicated by issues of ownership, and unclear managerial responsibilities. As a result, bat gates are often installed to secure important roosts, through reclamation and/or mitigation dollars, while responsibilities for monitoring the impacts of protective measures often fall under the purview of other management entities. In many cases, this transition of responsibility is unclear, or overlooked, leaving the ultimate success of these gating projects unresolved. Rio Tinto Minerals (previously known as U.S. Borax) has maintained mineral leases and mining claims in and around Death Valley National Park since 1887. As part of their active use of these leases and claims, U.S. Borax initiated surveys of abandoned mines for use by bats, and installed bat gates at all openings where use was detected. Following gate installation, we monitored the use of each opening with IR video, and attempted to quantify internal climates by installing data loggers throughout these mines. Data collected from these surveys is currently being used to create a management plan that will be turned over to the California Department of Fish and Game and the State Lands Commission upon expiration of leases in 2007. In this presentation we will discuss specific patterns of use of these mines, the implications for management, and the importance of continuity of management actions during changes in stewardship.

Periodic Arousals and Winter Energy Budgets of Big Brown Bats (*Eptesicus fuscus*) in a Building Hibernaculum

Amy L. Fairbairn, Justin G. Boyles, and John O. Whitaker, Jr., Indiana State University, Terre Haute, IN

Determining the total energy needed during winter and appropriation of that energy to various activities is important in understanding the nature of hibernation. Winter energy budgets have been necessarily simplified due to lack of data relating metabolic measurements to natural behavior and ecology. We predicted that big brown bats are arousing more often than previously documented due to the large amount of individual movement observed in preceding years resulting in high energy use. We also predicted that the widely fluctuating temperatures in the hibernaculum would lead to bats commonly using passive rewarming to save energy. We measured skin temperature of big brown bats (*Eptesicus fuscus*) inhabiting an attic in western Indiana throughout winter using a data logger attached to the interscapular region. Torpor bouts and arousals lasted for a mean of 3.3 days and 4.98 hours respectively. Big brown bats maintained a pattern, which allowed them to arouse near dusk providing feeding, drinking, and roost switching opportunities. A larger proportion of bats woke for longer periods on warmer days, but ambient temperature during torpor did not correlate with torpor bout length. For a hypothetical 90 day hibernation period bats used a total of 93.57 kilojoules (kJ): 40.08 kJ during torpor, 22.40 kJ in the active arousal, 16.08 kJ in the active phase, and 15.01 kJ cooling. Passive rewarming was used by 5 of 7 bats and lead to 18% energy savings compared to active arousals.

Passive rewarming resulted in energy savings that have been excluded in previous calculations of winter energy budgets.

Distribution of Eastern Pipistrelles (*Pipistrellus subflavus*) in Southwest Nova Scotia Relative to Site and Landscape Factors

Lesley Farrow and Hugh G. Broders, Saint Mary's University, Halifax, NS

The eastern pipistrelle (*Pipistrellus subflavus*) in Nova Scotia has a restricted range, exhibits distinct behavioral and morphological characteristics, and is likely disjunct from conspecific populations. In the region they require clumps of Usnea lichen for roosting, which is typically found in mature spruce trees. This association may make this population vulnerable to forest alteration. The objective of this research is to increase local knowledge of eastern pipistrelle ecology in Nova Scotia, contributing towards their conservation. Specifically, we monitored the activity of eastern pipistrelles at 100 river sites (40 in 2005 and 60 in 2006) throughout southwest Nova Scotia using six Anabat II detectors to: 1) determine the regional distribution of the population, 2) quantify the effects of landscape and site-level factors on species activity and 3) assess the value of a systematic acoustic survey program for monitoring landscape elements associated with high eastern pipistrelle activity. Preliminary results from the first year of monitoring indicate that, of the landscape level variables, area of water resources and mature spruce forest are the best predictors of presence or absence of eastern pipistrelles. Ongoing analyses will attempt to refine our understanding of effect sizes and incorporate both years of data.

An Energetic-Based Individual Model for Insectivorous Temperate Bats

Paula Federico, Thomas G. Hallam, and Dobromir Dimitrov, University of Tennessee, Knoxville, TN

Temperate zone bats are subject to serious energetics constraints due to their high surface area to volume relations, the cost of temperature regulation, the high metabolic cost of flight, and the seasonality of their resources. To our knowledge, there are no individual-based mathematical models for any bat species. The model developed here for a female bat is primarily based on life history and energetics. It describes the growth of an individual female bat using a system of differential equations modeling the dynamics of two main compartments: storage (lipids) and structure (proteins and carbohydrates). The model is parameterized for the little brown bat, *Myotis lucifugus*, because of information available on energy budgets and changes in body mass throughout its life history. However, with appropriate modifications the conceptualization might be applied to other species of bats with similar life histories. A corroboration of the model is not completely possible due to the lack of independent data set of that used to construct and calibrate the model. However, the dynamic estimates of daily energy budgets resulting from the model reasonably compare to previous estimates obtained through other different methodologies. Sensitivity analysis using statistical screening design techniques identifies the individual parameters driving the model output and indicates the individual characteristics that might play an important role in survival, reproduction, and consequently in population dynamics of temperate zone bats.

Flower Bat and Bird Niches in Two Worlds: a Pantropical Comparison

Theodore H. Fleming and Nathan Muchhala, University of Miami, Coral Gables FL

Bats and birds have independently evolved pollinator mutualisms with flowering plants in the New and Old World tropics. Despite superficial similarities in these plant animal interactions, there exist some profound differences in the structure of New and Old World vertebrate assemblages regarding their species richness, degree of morphological and feeding specialization, and the ways in which pollinators partition floral resources. Compared with Old World assemblages, New World assemblages contain more species with specialized morphology and specialized feeding habits that partition floral resources more finely. In this paper we discuss possible ecological and evolutionary reasons for these hemispheric differences. One fundamental reason for these differences is that New World nectar feeding bats and birds are substantially smaller than their Old World counterparts. Body size profoundly influences many aspects of plant pollinator interactions, including feeding energetics and maneuverability on the pollinator side as well as many floral characteristics. The existence of small, hovering nectar feeding bats and birds in the New World has favored the evolution of more specialized plant pollinator interactions in the neotropics than in the paleotropics.

Habitat Selection of Over-wintering Red Bats, *Lasiurus borealis*, in South-central Missouri

Josh R. Flinn and Lynn W. Robbins, Missouri State University, Springfield, MO

The eastern red bat, *Lasiurus borealis*, occurs in forested areas throughout eastern North America and its winter roosting habitat has been described in oak/hickory/cedar forests in southwest Missouri. Previous research has documented cedars and oaks as the primary roost tree species and that leaf litter on the forest floor is utilized when temperatures drop to near or below freezing. We studied the roosting ecology of red bats in a mixed pine/oak/hickory forest in south-central Missouri during the 2005-06 winter season (November – March). Tree (n=19) and leaf roosts (n=30) were recorded for sixteen radio-tagged male red bats. Forest landscape measurements were recorded at roost sites and compared to random sites. We used Hobo 2-channel data loggers to simultaneously record leaf-litter and ambient temperatures at roosts to explore relationships between temperature and roost choice (tree vs. leaves). Red bats roosted on the south side of trees and on south facing hillsides, primarily in oaks with persistent leaves. One pine and one hickory tree were used. Tree roost sites were significantly different from random sites. Roost sites were at higher elevations, and the roost trees were shorter and had smaller diameter at breast height. Leaf roosts occurred on south facing slopes and were characterized by higher elevation, deeper leaf litter, greater percent litter cover, and more woody stems than random sites. Ambient and leaf temperature data and their relationship to roost choice will be presented. While our study indicates that red bats select deciduous rather than coniferous roost trees when pines (as opposed to cedars) are the dominant evergreen, it also corroborates previous descriptions of selection of south facing hillsides for both tree and leaf roost sites.

Opportunistic Videography of Maternity Roosting Behaviors of a Colony of Townsend's Big-Eared Bat (*Corynorhinus townsendii*)

Kiera A. Freeman and Joseph M. Szewczak, Humboldt State University, Arcata, CA

Located in the Tahoe National Forest near Sierra City, California, the Kentucky Mine Historic Park includes a museum and a stamp mill that hosts a maternity colony of Townsend's big-eared bat, *Corynorhinus townsendii*. Although twice daily tours through the stamp mill frequently pass directly beneath the roosting females, this colony has acclimated to this level of disturbance typically considered intolerable for this species. The acclimation of these bats to human presence has created an opportunity allowing us to regularly enter the roost to observe this colony without concern for disturbing or influencing their activity. We investigated microclimate preference, behavioral thermoregulation, and how this may be influenced by different periods in the maternity cycle. We assessed bat activity and location within the roost during the maternity cycle by video recording the colony using a Sony DCR-TRV520 Nightshot Camera equipped with a high intensity external infrared lamp. While processing this video data we observed additional behaviors facilitated by the unexpected quality of the video images and during the following season focused on detailed recording of behavioral observations and to create an interpretive display for the park museum. Although many of the observed behaviors of allogrooming, birthing, and retrieval of a fallen pup, mother-young recognition, and hygienic waste elimination have been previously described in the literature, they have not been tracked through a complete maternity season or video recorded with this much detail. We will present video highlights of these behavioral observations and discuss their behavioral relevance.

*Island Biogeography and Community Ecology of Bats in Baja California, Mexico

Winifred F. Frick, John P. Hayes, and Paul A. Heady III, Oregon State University, Corvallis, OR; Central Coast Bat Research Group, Aptos, CA

*** Winifred Frick** received the **Karl F. Koopman Award**

Island biogeography has played a pivotal role in shaping ecologists' understanding of patterns of species richness and composition in patchy landscapes. We examined the influence of island characteristics (size, isolation) on bat richness in two subarchipelagoes in the Gulf of California, Mexico using multiple linear regression and AIC model selection procedures. The best-fit parallel slopes model of bat richness as a function of both $\log_{10}$area and isolation for the two subarchipelagoes demonstrates that area and isolation and habitat conditions are all important factors in shaping insular bat communities. Isolation had a surprisingly strong effect on bat richness, with a decrease of 1 species for every 11 km further away from the Baja peninsula. We examined the nested subset structure of bat community composition across the entire archipelago using program BinMatNest. The presence-absence matrix of eight bat species columns across 34 island rows was significantly nested when compared to 1,000 Monte Carlo simulations based on a null model algorithm that accounts for both species occurrence and island richness totals (null 3). Although strong nestedness indicates deterministic factors shape community composition, identifying underlying processes can be difficult to tease apart. We compared the correlation of nested rank order to island factors (size, isolation) to determine their importance in shaping insular community structure. Area was strongly correlated with nested rank order (Spearman rho = 0.58, $p < 0.0003$) and isolation was correlated with nested rank order after partialling out the effects of area (Partial Spearman rho = 0.47, $p < 0.005$), indicating both area and isolation contribute to nested subset structure in this system.

Assessment of Ecological Associations of Bats in Northern Alabama

Sara E. Gardner, Troy L. Best, Charles H. Kilgore, and Lisa A. McWilliams, Auburn University, AL

The bat fauna of Alabama includes 15 species. Two are listed as endangered by the United States Fish and Wildlife Service (*Myotis grisescens* and *M. sodalis*), five are protected in Alabama (*M. austroriparius, M. grisescens, M. sodalis, Corynorhinus rafinesquii*), and state-listed species of 'special concern' and 'poorly known' include *Lasiurus intermedius, M. austroriparius, C. rafinesquii,* and *Tadarida brasiliensis*. Relatively little is known about bats in Alabama, but considerable research has been conducted within the past decade. Bats occurring in northern Alabama are of special interest because two endangered species are known from the area. In preparing management plans, it would be useful to know if both of these species are present and what habitats they may occupy. We mist-netted for bats during the summers of 2005 and 2006 at a total of 124 sampling sites. Seven of the 15 species of bats that occur in Alabama were captured including one endangered species, *M. grisescens*. Distribution, habitat, age-class, and sex-ratios are being analyzed for each species. These data will be useful in developing management plans for bats in northern Alabama, and they will provide baseline data for comparisons and future research. This study will be a significant contribution to overall assessment of presence, distribution, and habitat associations of endangered bats in Alabama. Preliminary results will be presented.

Eavesdropping by Bats on the Feeding Buzzes of Conspecifics

Erin H. Gillam and Gary F. McCracken. University of Tennessee, Knoxville, TN

Echolocation calls of most bats are loud in amplitude, and as a result are subject to eavesdropping by nearby conspecifics. Bats approaching an insect modify their call structure, and emit a distinct train of short duration calls immediately before capture known as a “feeding buzz”. Previous studies have shown that bats are more strongly attracted to playback signals that contain feeding buzzes compared to those that lack these calls. Yet, these studies did not control for signal characteristics of the playback stimuli other than the presence/absence of feeding buzzes. To further test if bats are attracted to conspecific feeding buzzes, we presented free-flying *Tadarida brasiliensis* with pre-recorded echolocation call sequences in which feeding buzz calls were either present or absent, and all other sequence characteristics were kept constant, as well as a silence control. We assessed levels of bat activity by counting the number of echolocation calls recorded in the presence of each of these broadcasts, and found significantly greater bat activity in response to sequences that contained feeding buzzes compared to sequences in which feeding buzzes were absent, or silence. These results indicate that bats eavesdrop on the calls of nearby conspecifics, and likely use the information obtained from eavesdropping to more readily locate rich patches of insect prey.

Rapid Jamming Avoidance in Biosonar

Erin H. Gillam, Nachum Ulanovsky, and Gary F. McCracken, University of Tennessee, Knoxville, TN; University of Maryland, College Park, MD

The sonar systems of bats and dolphins are in many ways superior to man-made systems, and considerable effort has been devoted to understanding the signal-processing strategies underlying these capabilities. A major feature determining the efficiency of a sonar system is its sensitivity to noise and jamming signals. Previous studies indicate that echolocating bats may adjust signal structure to avoid jamming. However, these studies relied on behavioral correlations and not controlled experiments. Here we provide the first experimental evidence for a jamming avoidance response in animal sonar. We presented bats (*Tadarida brasiliensis*) with ‘playback stimuli’ consisting of recorded echolocation calls shifted to one of six frequencies. The bats exhibited a jamming avoidance response by shifting their call frequency away from the playback frequency and increasing call bandwidth. Approaching bats challenged by an abrupt change in the playback stimulus responded by shifting their call frequencies upwards, away from the playback. Surprisingly, even bats initially calling at frequencies below the playback shifted upwards, essentially ‘jumping’ over the playback frequency. These spectral shifts in call structure were rapid, often occurring within the first echolocation call emitted after the switch. The observed responses give insight into the signal-processing capabilities of animals that use active sensing.

Populations Fluctuations of *Tadarida brasiliensis mexicana* along its migratory route in Northeast and South México

Alejandro Gómez-Nísino & Rodrigo A. Medellín, UNAM, México, D. F., México

Tadarida brasiliensis mexicana migrates from the center and southwest of EU to central and southern México on winter. Later the females return to the north caves for breeding in the summer. Faced with the lack of information about seasonal movements along the migratory routes in México emerge the interest to carry out this study. The objective was to document population fluctuations in 3 representative caves in northeast, east-central and southeast México along the migratory route: “La Boca”, Santiago, Nuevo León, “El Salitre”, Metztitlán, Hidalgo and “San Francisco”, La Trinitaria, Chiapas. The data consist of bimonthly censuses from May 2005 to August 2006 in each cave using a video-camera filming the colony during evening emergency and recording the time for a posterior laboratory analysis. The results indicate that the central and south populations are present year-around and in the north cave they are absent from December to April. Population magnitudes are very different (La Boca 4000 to two million, El Salitre from a few hundreds to 110,000 and San Francisco from one thousand to 650,000) and fluctuate seasonally, being more abundant in the wet season (June ‘06, June ’05, respectively) and scarce in middle of the dry season (March ‘06). These numbers are contrary to literature reports, although there are no early precise demographic or movement studies with this species in the country. The La Boca population follows the typical migratory pattern of south Texas.

Banana Plantations as Refuges for Nectar-Feeding Bats in Western Mexico

Tania P. González Terrazas, Rodrigo A. Medellín, UNAM, México

In Mexico there are 12 species of glossophagines. Two species are endemic to the country (including a monotypic genus) and 2 species endemic to Middle America. Most nectar feeding bats are associated with tropical and subtropical dry areas. Because of its many endemic species and large extension in the Mexican Pacific coast, tropical dry forest is the most important vegetation type; it is also the most perturbed, utilized and least conserved of the Mexican large tropical ecosystems. Banana plantations are one of the most important agricultural crops in the zone. *Musa* spp. plants have nectar-rich flowers, and banana plantations have flowers throughout the year. Because of this we wanted to understand the importance of banana plantations as a refuge for the community of nectar-feeding bats. We mist-netted bats in banana plantations from sunset to 3:00 a.m. during four ten-day sessions, two in dry season and two in rainy season. The nets were placed in front of fresh banana flowers. We did the same in other potential feeding sources, to understand resource use by nectar-feeding bat species and by season. We found that nectar-feeding bats use banana plantations throughout the year, but most frequently in the rainy season when there are no other resources available in the dry tropical forest and disturbed areas. The threatened *Leptonycteris* seems to use banana plantations very consistently throughout the year, whereas *Glossophaga soricina* is an opportunistic species that can use extensive blooms of disturbed vegetation, besides banana and forest. The endangered banana bat (*Musonycteris harrisoni*) seems to use forest consistently, but it also uses banana plantations.

Physical and Environmental Characteristics of Bat Houses Affecting Bat House Use by Little Brown Bats, *Myotis lucifugus*

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The purpose of this research was to monitor the activity of *Myotis lucifugus* in bat houses on the Chautauqua Institution grounds in Mayville, NY. Chautauqua Institution is located on Chautauqua Lake and includes many old buildings that have historically housed and are currently housing the largest population of little brown bats in Western New York. With an increasing number of homeowners renovating and excluding bats from attics, it may be necessary for bats to find alternative roosting sites. The physical and environmental features of fifteen previously mounted bat houses were observed based on an adapted Bat Conservation International 2005 Bat House Report Form. We monitored bat house use by noting presence/absence of bats and guano and maximum number of bats observed. Several physical and environmental features were significantly associated with bat occupancy including color of the bat house, kind of mounting structure, and color of the structure (all likely associated with bat house temperature), and distance to Chautauqua Lake. Additional features associated with bat occupancy included specific type of bat house, size category (small, medium, and large), thickness of exterior wall, and the width and height of crevices.

Do the Ultrasonic Vocalizations of Big Brown Bats (*Eptesicus fuscus*) Influence Mate Selection?

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Acoustic signals, ranging from infrasonic (<10Hz) to ultrasonic (>20,000Hz), are an important method of communication among many species including insects, fish, amphibians, birds, and mammals. Furthermore, communication signals are important regulators of mating behavior in most mammal species, but the mechanisms involved in courtship and mating are not well understood. Although bats are known for their use of ultrasound for navigation and foraging, there is less evidence for its use in a social context. Recently, research demonstrated that the ultrasonic vocalizations differ between the sexes seasonally, and that these differences are correlated with copulation success. In these experiments, we used playbacks to test if the ultrasonic vocalizations of big brown bats are used for mate preference. Sixteen adult male and 40 adult female big brown bats (*Eptesicus fuscus*) were used as subjects in choice trials. We measured subject response (i.e., call rate, first choice, and time to make a choice) to natural and synthetic ultrasonic calls played from speakers placed outside a wire screen arena. We found that reproductively active males were more likely to choose the ultrasonic vocalizations of females with the highest copulation success. We did not find a significant difference in female response to the ultrasonic vocalizations of males with differing copulation success rates. These results provide preliminary evidence that ultrasonic calls provide information that influences mate selection in males of this species.

Behavioral Responses of Bats to Passive Integrated Transponder Reader Gates at Three Indiana Bat (*Myotis sodalis*) Hibernacula Near Bloomington, Indiana, Spring 2006

Mark Gumbert, Eric Britzke, Piper Roby, Price Sewell, and Mathew Hohmann; Copperhead Consulting

Army installations are required to develop Endangered Species Management Plans for all threatened and endangered species on their property. This can be difficult for migratory species such as Indiana bats (*Myotis sodalis*) that spend part of the year off-site. Indiana bats roost in the summer on Camp Atterbury, Indiana, but it is not known where all of the population hibernates in the winter. Because the recovery of arm bands from Indiana bats is extremely low as a mark-recapture method, the use of passive integrated transponder (PIT) tags may give better insight into where known summer colonies are hibernating. Bats were PIT-tagged on Camp Atterbury in Summer 2005 and three caves near Bloomington, Indiana were monitored for these bats in Spring 2006. Fly-through antennae that read the tags were placed in the entrance of these caves so that any tagged bats would be recorded as they exited or entered the cave. The gates allowed for 18-25% of original flight space through the entrance of the cave. There were no PIT-tagged bats detected at these caves, but video analysis of bat behavior at the caves provided evidence that the gate readers were not hindering normal bat activity. The most common bat behavior at the caves was circling (average = 63%) while collisions accounted for only 0.83% of all behavior on average. Collisions were highest at Clyfty Cave which had restricted space for circling behind the gate. Gates that are erected to monitor for PIT-tagged bats should be placed such that sufficient area is available for circling activity. Also, bat activity should be video recorded when gates are erected to determine how gates are affecting bat behavior. This will be important for long term studies at individual hibernacula; if the numbers of collisions or landings are high, the gate could be adjusted to reduce these occurrences.

Morphometric Distinctiveness, Taxonomic Status, and Conservation of *Pteronotus parnellii* on the Península de Paraguaná in Northwestern Venezuela

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In Venezuela, three subspecies of *Pteronotus parnellii* are recognized (*P. p. paraguanensis*, *P. p. fuscus*, and *P. p. rubiginosus*). We used Principal Components to extract the size and shape constituents of 7 appendicular (limb) and 27 cranial measurements of 267 Venezuelan specimens of the three subspecies aforementioned, and Cluster Analyses to classify the specimens according to their shape. The most important results are: (1) the endemic subspecies of the Península de Paraguaná (*P. p. paraguanensis*, n = 25) differs greatly from the other subspecies in being smaller and in having different shape, in both appendicular and cranial features; (2) *P. p. fuscus* (n = 117), which occurs in the mainland to the north of the Llanos, and *P. p. rubiginosus* (n = 125), which occurs south of the Río Orinoco, also differ notably in appendicular and cranial size and shape, although to a lesser degree than either of them with respect to the highly distinctive *P. p. paraguanensis*. Therefore, we propose that *P. p. paraguanensis* be promoted to species rank, and we emphasize that special measures are required for its conservation. Based on their differences in size and shape, *P. p. fuscus* and *P. p. rubiginosus* may also represent full species, but studies using other techniques and samples from their entire distributional ranges and that of the nominotypical subspecies, *P. p. parnellii* (Jamaica), are required to determine their taxonomic status. The differentiation of *P. p. fuscus* and *P. p. rubiginosus* may be the result of the tight forest dependence of these bats, which keeps them isolated by the savanna corridor of the Venezuelan and Colombian Llanos.

Pre-closure Surveys of Fifty-two Abandoned Coal Mines in Western Maryland

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Abandoned mines in western Maryland pose a public safety hazard, yet provide critical habitat for bats in the form of hibernacula and migratory stop-over sites. In the late 1990's, the Maryland Department of the Environment, Bureau of Mines, conducted site visits at >850 known underground coal mines in Garrett and Allegany counties of western Maryland. These visits determined that 52 of the mines had open portals that needed to be closed to prevent human access. Pre-closure surveys were conducted in the spring and fall 2006 to determine whether bats were present and which species. Surveys were conducted with Anabat II bat detectors, harp traps, and mist nets. Spring surveys totaled 17 trap nights and 241 acoustic monitoring nights. At the conclusion of the spring surveys, bat use was confirmed at 14 mines whereas 9 mines could not be determined for bat use. Of the remaining mines, 3 were not accessible to bats due to obstructions over the portal such as vegetation or fencing, 13 were recommended for closure based on size, 10 had collapsed, and 3 were not surveyed due to access restrictions. The following bat species were found during the surveys: little brown myotis (*Myotis lucifugus*), eastern pipistrelle (*Pipistrellus subflavus*), and the northern myotis (*Myotis septentrionalis*). Fall surveys will continue through November 2006 and concentrate on the 14 mines confirmed for bat use and the 9 mines undetermined for bat use. Survey results will be used by the Bureau of Mines to determine which mines will be protected with bat gates and which mines will be closed.

A Molecular Perspective on the Evolution of Olfaction in Bats

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Since their discovery in the rat over a decade ago, Olfactory Receptor (OR) genes have been detected in many orders of birds, fish, amphibians and mammals. Comprising nearly 1% of the mammalian genome, OR genes make up the largest gene family, consisting of approximately 1000 different genes. Each OR gene codes for an olfactory receptor that binds to an odor molecule inducing a signaling cascade to the olfactory bulb in the brain, enabling organisms to perceive a myriad of odors. There appears to be a negative relationship between visual and olfactory capabilities in mammals. It has been shown in primates that the gain of full trichomatic (color) vision has resulted in the degradation of olfactory capabilities, through the loss of function of many OR genes. As the majority of bats are nocturnal sensory specialists that have acquired the capability of laryngeal echolocation, they are the perfect models to elucidate if this sensory 'trade-off' occurs in other non-primate mammals with different sensory specializations. To investigate the genomic consequence of environmental niche specialization in bats, the full repertoire of OR genes were amplified and sequenced in an echolocating microbat (*Pteronotus parnellii*) and a non-echolocating megabat (*Nyctimene albiventer*). The bat OR genes were classified into class and family and the percentage of functioning and non-functioning olfactory receptor genes were elucidated. These results were compared with other mammals.

Selection of Abandoned Mines as Hibernacula by Townsend’s Big-Eared Bat (*Corynorhinus townsendii*) in Southwestern Colorado

Mark A. Hayes, Kirk W. Navo, Rob A. Schorr and Rick A. Adams, University of Northern Colorado, Greeley, CO; Colorado Division of Wildlife, Monte Vista, CO; Colorado Natural Heritage Program, Fort Collins, CO

Townsend’s big-eared bat (*Corynorhinus townsendii*) is a hibernating species of conservation concern in western North America. The Colorado Division of Wildlife’s Bats/Inactive Mines Project has been conducting internal surveys at abandoned mines in Colorado since the late 1990’s, with an emphasis on finding and protecting mines occupied by this species. To help guide inference about which variables may influence hibernacula selection, we conducted a retrospective analysis of *C. townsendii* hibernacula in southwestern Colorado by analyzing the results of internal surveys conducted at 136 abandoned mines during January, February, and March from 1999-2006. Prior to analysis, we developed a set of 11 candidate models based on 4 mine-site variables (site complexity, portal aspect, portal airflow, and number of openings). We hypothesized that these variables are important in promoting stable, low temperatures in abandoned mines during the winter season. We used logistic regression and an information-theoretic approach to evaluate and guide inference from the set of candidate models. We created a balanced model set and accepted models for inclusion in the analysis if they yielded a Hosmer-Lemeshow goodness-of-fit P-value of >0.10. Surveys documented 105 *C. townsendii* in 45 mines (33% of mine sites surveyed), with an average of 2.33 individuals found per occupied mine. Of the models tested, “Airflow + Aspect + Complexity + Openings” and “Airflow + Aspect + Complexity” yield the highest AICc weights (0.363 and 0.321). Hibernacula tended to be in complex mine sites with multiple openings, unidirectional airflow at the portal, and north-west, west, and east facing portals.

The Development of Long-Duration Acoustic Bat Detectors for Southeast Alaska

Matt Heavner, University of Alaska Southeast, Juneau, AK

A new, low-power, computer-based acoustic sensor for long-duration (~100 days) observation of bats has been developed. This poster will describe the system and the development decisions driving the final design of the system, specifically the tradeoffs between power consumption, processing power, and scientific and monitoring needs.

Long duration monitoring of several different types of areas (such as old-growth vs 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 and deployment strategies for Southeast Alaska will be described.

Acoustic Monitoring of Southeast Alaska Bats

Matt Heavner, Carrie Talus, and Allan Hall, University of Alaska Southeast, Juneau, AK

During 2005 and 2006 summers, over 80 hours of acoustic observations of bats were made in southeast Alaska. Using this data, the nightly activity of bats was examined for 23 different sites located in two different areas of southeast Alaska, Prince of Wales Island and Juneau. An Anabat II detector was used to record night-time (pre-sunset to post-sunrise) acoustic activity. Each site was analyzed for presence of bats, activity patterns, and total activity, using the number of pulses per ten minute period as a measurement of activity. For each site, data was also recorded on elevation, karst, forest age, and proximity to water source. During 2006 insects were collected using a light trap at each location. The analysis of the data will be presented. The efficacy of long duration acoustic monitoring for addressing management issues in southeast Alaska is described.

Modeling Roost-site Selection of Seminole Bats (*Lasiurus seminolus*) at Multiple Spatial Scales on an Intensively-managed Forest in the Lower Coastal Plain of South Carolina

Cris D. Hein, Steven B. Castleberry, and Karl V. Miller, University of Georgia, Athens, GA

As demand for forest products increases, management practices are expected to become more intense, potentially resulting in reduction of late successional forests and decline in floral species diversity. Because these changes may negatively impact the availability of suitable roosting habitat, it is important to understand roost-site selection of forest-dwelling bats. From May to August 2003-2006, we used radio-telemetry to investigate roost-site selection of Seminole bats (*Lasiurus seminolus*) in response to landscape-level forest management on 41,365 ha of intensively-managed forest owned by the MeadWestvaco Corporation in the Lower Coastal Plain of South Carolina. A total of 29 bats were tracked to 93 roosts. Seminole bats roosted exclusively in foliage of live loblolly pine (*Pinus taeda*) trees. We collected habitat and landscape-level data for each roost tree and an equal number of random trees. Selection of roost sites will be modeled using logistic regression. Akaike's Information Criterion for small samples (AICc) and Akaike weights will be calculated to evaluate and select the most parsimonious model relating roost-site selection to tree, plot, stand, and landscape-level variables. Results of model selection will be presented along with management implications.

Movements and Characterization of Foraging and Roosting areas for the Forest-Dependent Northern Long-eared Bat (*Myotis septentrionalis*) in a forest-agriculture landscape

Lynne E. Henderson and Hugh G. Broders, Saint Mary's University, Halifax, NS

Landscape mosaics of forests and agriculture have become a dominant feature across many regions of North America. For forest dependent bats, the expansion of agriculture may act to degrade the landscape by limiting essential resources such as roosting sites and foraging areas. The history of human settlement on Prince Edward Island is directly linked with the current distribution of the island's forests. The expansion of agriculture has changed the historical forest cover of the island from a nearly continuous entity to a complex mosaic of forest patches embedded in an agricultural matrix. The northern long-eared bat (*Myotis septentrionalis*) is a forest interior species that roosts and forages exclusively in the forest interior. The goal of the second year of our study was to assess how forest bats move within a landscape composed of fragmented forests. Specifically, we wanted to characterize foraging and roosting areas spatially and vegetatively, and track the movements of individuals within and among these areas. We tracked individuals from two separate colonies in two landscapes that differed in spatial configurations. We attached radio-transmitters to twenty-one female northern long-eared bats from June to August 2006 to locate day roosts and track foraging movements at night. Bats were found to roost predominantly in maples (*Acer* spp.) and also within a barn. Foraging movements were centered along forest covered creeks and commuting movements between roosting and foraging areas were concentrated along hedge-rows and forest-field edges. We never tracked individuals flying over open areas.

Why do Bats Switch Roosts? A Case Study in the Foliage-roosting Bat (*Myotis formosus*) in Taiwan

Ying-Yi Ho, University of Western Ontario, Ontario, Canada

Bats show varying degrees of roost fidelity. In general, forest-roosting bats usually switch roosts frequently but show a high fidelity to a small roosting area rather than roosting sites. The reasons for the short term switching are not clear. Normally, behavior such as movements between alternative roosts is costly. The cost could reflect increasing risk of predation, lowering familiarity with foraging opportunities, disrupting social bonds, and energy costs associated with finding new roosts. Factors such as predation, parasitism, disturbance, foraging range, roost microclimates and social association have been proposed to be related to the causes or function of why bats switch roosts frequently. To date, most of the inferences were drawing from species level studies. The intraspecific variability in roost fidelity is rarely investigated. During the past three summers, I used wing-banding and radio-tracking to study roost switching and association patterns of foliage-roosting bats, *Myotis formosus*, in the south-western plain in Taiwan. In total, 88 *M. formosus*, including different sexes, ages, and reproductive status, were followed by either individual-specific colored bands or radio-tracking, and their day roosts were located and recorded. More than 1000 bat-day daily census data were analyzed. Analysis to date showed that environmental and social factors as well as reproductive condition have effects on their roost switching frequency. Moreover, the roost could be abandoned by the whole group simultaneously rather than by a few individuals. The relative importance of various factors will also be discussed.

Forest dwelling bat responses to forest restoration: techniques and preliminary results

Valerie J. Horncastle, Mylea L. Bayless, and Michael Ingraldi, Arizona Game and Fish Department, Phoenix, AZ

Ponderosa pine forests are being treated on Camp Navajo using restoration prescriptions to restore ecosystem function. We are studying the effects of ecosystem restoration on forest dwelling bats within this community. In March of 2004, we constructed 288 artificial tree roost boxes and attached them to live trees in clusters of 24. We randomly stratified the placement of these clusters within three treatment types (thin, thin and burned, and deferred) maintaining similar slope (0% - 30%) and aspect (90° - 270°) for all bat boxes. In April 2005, an additional 288 bat boxes were placed on Camp Navajo and temperature sensors were placed in all 576 boxes. Pre-treatment data was collected in 2004 and 2005 for subsequent comparison to post-treatment data. Bat boxes were checked for occupancy several times throughout the summer. Bats were removed from bat boxes and color banded for visual confirmation of species and treatment areas where bats were captured. In 2004, we captured and marked 29 bats consisting of six species: *Myotis occultus, Eptesicus fuscus, Myotis evotis, Myotis volans, Myotis thysanodes* and *Myotis auriculus*. We observed a 35% return rate for all marked bats. Bats occurred more often in south and west facing boxes. In 2005, we captured and marked 87 bats consisting of the same 6 species. We observed a 40% return rate for all marked bats. Bats occurred more often in east facing boxes. In our poster, we discuss the methodology used to monitor bats and preliminary evidence that bats will return to artificial boxes after disturbance using these methods. The influence of bat box temperature and orientation on bat occupancy will also be discussed.

Ontogeny of Play Behavior in Captive *Pteropus rodricensis*, the Rodrigues Fruit Bat

Becky A. Houck and Julie Kunrath, University of Portland, Portland, OR

Social play behavior was first described in *Pteropus rodricensis* by in 1979. We have examined the ontogeny of play behavior in juvenile *Pteropus rodricensis* at the Oregon Zoo. We observed play wrestle and play chase in both juvenile and adult captive *Pteropus rodricensis*. No play behavior was observed in infants before 130 days of age. Play behavior developed rapidly after this age. In a focal study of one juvenile between 156 – 193 days of age, play was the largest single category of behavior observed.

Lessons in History: Colony Size and Population Decline of Brazilian Free-Tailed Bats at Carlsbad Caverns

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

The colony of Brazilian free-tailed bats (*Tadarida brasiliensis*) at Carlsbad Caverns is one of several well-known colonies of this highly gregarious and conspicuous species in North America. For over 80 years researchers have attempted to estimate the size of this colony with mixed results. Primitive methods and lack of repeatability have resulted in questionable estimates giving rise to poorly understood but highly popularized long-term trends. In this study, we present the most accurate and complete, seasonal, colony size estimates to date, based on a new census method, advanced thermal infrared imaging and computer vision processing. The size of the colony was estimated monthly from March through October in 2005 and 2006. Our results indicate large changes in the size of the colony within the same season and between seasons. Colony size estimates range from 23,660 to 793,838 bats, values that are lower than historical estimates for this location. In addition, consecutive daily estimates show large fluctuations in the size of the colony by as many as 290,000 individuals indicating that the colony is considerably more dynamic than previously suggested. Using realistic 3D simulations, paired with additional quantitative analyses of bat emergence behavior, we raise questions about the validity of early historic estimates that millions of bats once roosted in this cave, and prompt a reevaluation of the long-term pattern of decline that has been suggested for this species. The answer to these questions requires accurate, base-line data that incorporate seasonal and long-term observations. Thermal infrared imaging and computer vision processing provide a highly effective and reliable method for the accumulation of such data as has been demonstrated in the present study.

The effect of artificial loads on the straight flight performance of fruit bats

Jose Iriarte-Diaz, Brown University, Providence, RI

Most bats experience significant fluctuations in their body mass. These fluctuations can be both daily, mostly due to feeding, or seasonal due to fat storage and/or reproduction. Based on predictions derived from classic aerodynamic theory, increments in body mass, such as those in observed in natural populations of bats, should severely affect their flight performance. But because bat flight is spatially and temporally complex, and bat wings continuously change shape during a wingbeat, the utility of such theoretical models is limited. For example, some bats species are able to increase their body mass up to 40% and remain capable of maneuvering in complex three-dimensional environments. How increased lift is produced when weight is increased is well understood. Thus, the purpose of this study is to evaluate the effect of added mass on the kinematics of forward, steady flight in a fruit bat. Three lesser short-nosed fruit bats (*Cynopterus brachyotis*) were trained to fly in a flight corridor with and without carrying a load of about 20% of their original body mass. Ultra-light reflective markers were placed on the body and wings and flights were recorded with three synchronized, high-speed digital video cameras in low light conditions. Data from the three cameras were combined to reconstruct the 3D motion of each marker. From these recordings, flight speed and body and wing kinematic parameters were obtained for each treatment. Experimental bats showed a 27% increase in speed with a 20% increase in body mass. Wingbeat frequency and amplitude, however, did not change with load, suggesting that more subtle changes in wing configuration (e.g., angle of attack, camber) must be used to generate enough lift to compensate for the increased weight.

Differential Use of Pinyon-Juniper Woodland Habitat by Townsend’s Big-Eared Bats (Corynorhinus townsendii) in Pershing County, Nevada

Robin R. Ives, Richard E. Sherwin, Jenni Jeffers, Samuel L. Skalak, Dave Dalton, and Sandy Wolf, Christopher Newport University, Newport News, VA; Nevada Department of Wildlife, Fallon, NV; Wildlife Engineering, Tucson, AZ

Over the past 150 years, harvesting, warming climate, heavy livestock grazing, and decreased fire frequency have dramatically impacted piñon-juniper woodlands. Considered unproductive by some range managers, piñon-juniper woodlands have been controlled by prescribed fires and mechanical removal. Although, conversion of western woodlands to shrub-steppe plant communities may increase avian and nonvolant mammal diversity, recent research has shown that several bat species may be reliant on piñon-juniper woodlands for foraging and roosting habitat. As part of this research, we investigated use of pinyon-juniper woodlands by Townsend's big-eared bats. We used radiotelemetry to follow bats from roosts to foraging areas in Pershing County, Nevada. Bats foraged in pinyon-juniper woodlands along with juniper sagebrush, sagebrush-steppe, desert-scrub, salt-scrub, and desert grasslands. While at larger spatial scales we observed variations in habitat associations, we found strong affinities among individual colonies and specific habitat types. For example, we recorded individuals traveling to foraging areas in pinyon-juniper woodlands located in excess of 15 km from day roosts. In this talk, we will discuss habitat and foraging associations, nightly patterns of activity, and implications for the management of Townsend's big-eared bats in Nevada.

Some new aspects of morphological variability in bats of the genera *Sturnira, Carollia,* and *Anoura* in Ecuador

Pablo Jarrín, Boston University, Boston, MA

The contemporary perception of biological diversity relies mainly on the molecular paradigm. Under this conceptual and operational framework, species are usually defined by their cohesion in phylogenetic hypotheses based on matrilinear phylogroups. By contrast, the classical approach to species delimitation has relied mostly on the assumption of discrete diagnostic characters, with little or no recognition of continuous variability. The absence of dialogue between molecular and morphological approaches creates a black hole in the understanding of true biological diversity, and the possible mechanisms leading to speciation. The present study assesses basic properties in the variability of morphological characters related to size and shape in the skull of diverse and abundant Neotropical bats in the genera *Sturnira*, *Carollia* and *Anoura*. A discussion on the state of the taxonomy and evolutionary understanding of these bats is made in the context of (1) current proposed phylogenies based on molecular characters, (2) the established morphological diagnostic characters, and (3) the morphometric space of variability. Although these closely related species are coherent evolutionary aggregations as defined by the Phylogenetic Species Concept, the morphological space shows a degree of overlap in two or more continuous distributions, in which body size seems to be an important factor in the evolutionary dynamics of these groups. Available evidence argues that it is not currently possible to determine the identity of the studied species with full certainty, while using the diagnostic characters proposed in species descriptions and taxonomic treaties. Diagnostic characters should not be considered reliable without a previous assessment of their variability in all available samples used for the description of new taxa. A new taxonomic paradigm is necessary in which linear functions of characters and probabilities serve the purpose of species delimitation. These statistical definitions of species should benefit from available phylogenetic hypotheses based on molecular characters that will permit the calibration of taxonomical discriminant functions based on morphological characters.

Foraging Ecology of Long-legged Myotis (*Myotis volans*) in North-central Idaho

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

Effective conservation of bat populations will rely on accurate identification and conservation of foraging habitats. Data connecting prey availability, diet, habitat use, and home range may illuminate why bats will forage in one habitat over another. We radiotagged and tracked 70 adult long-legged myotis during the summers of 2004 and 2005 to obtain these data. Home ranges were estimated with the adaptive kernel method, and did not differ among males ($\bar{x}$ = 647 ha, n = 8), pregnant females ($\bar{x}$ = 448 ha, n = 10), or lactating females ($\bar{x}$ = 304 ha, n = 10). Second order habitat analysis, based on vegetation, showed that home ranges of males, pregnant females, and lactating females all were closest to stands of medium diameter trees, i.e., trees predominantly 12.7 – 38.0 cm dbh, that also contained larger snags used as roosts ($\bar{x}$ = 54.0 cm dbh; n = 100). Second order habitat analysis, based on slope position, showed that home ranges of males, pregnant females, and lactating females were closest to mid-slope positions. Third order habitat analysis, based on either vegetation or slope position, did not differ from random use for any sex or reproductive class. More Lepidopterans were captured in black-light traps at mid-slope positions than either upper or lower slope positions. Dissection of fecal pellets (n = 177) collected from 68 long-legged myotis revealed a diet primarily comprised of Lepidoptera (49.2 % volume, 100 % frequency) and Coleoptera (31.1 %, 100 %). These data demonstrate the importance of forest stand structure, topographic position, and abundance of moths to use of foraging habitat of long-legged myotis in north-central Idaho.

Pallid bat (*Antrozous pallidus*) habitat use in a coniferous forest in northeastern California

Dave S. Johnston and Jennifer R. Gworek, H.T. Harvey & Associates, San Jose, CA

Roosting and foraging habitat utilization must be considered when developing a bat management plan for a special-status species in a multipurpose forest. During the summer and fall of 2006 we used acoustic monitoring, mist netting, and radio-tracking to determine activity patterns of foraging and roosting pallid bats, a special-status species. Pallid bat roosting and foraging ecology has been studied in many environments, but little is known about the ecology of pallid bats in a mesic coniferous forest, such as that found in Plumas National Forest of the northern Sierra Nevada Mountains in California. Two non-consecutive night samples for each of 28 Anabat monitoring stations distributed along open ridge areas, in addition to acoustic monitoring data collected in 2002 by other investigators, helped determine the distribution of pallid bat activity. Bd-2 Holohill transmitters were attached to 11 bats to locate roosts and determine foraging areas for individuals. Pallid bat activity was greatest along flat ridge tops where bats foraged in an open mixed coniferous forest associated with short grassland habitat. By the end of August 2006, roosts were located primarily in incense cedar (*Calocedrus decurrens*) snags and damaged trees although one maternity colony was located behind the exfoliating bark of a sugar pine (*Pinus lambertiana*). Another maternity colony was located in a severely burned, but living, incense cedar with some individuals in a large underground root cavity and other individuals in a separate tree trunk cavity located about 5 m above ground. One female sub-adult visited 3 roosts in 1 evening. We intend to continue collecting roosting and foraging data for this year’s winter snow season and possibly for an additional 2 years.

Winter ecology of pallid bats in Central Coastal California

Dave S. Johnston, Bill Hepburn, Jennifer Krauel, Tom Stewart, and Daniela Rambaldini, H.T. Harvey & Associates, San Jose, CA; San Francisco Bay Bird Observatory; Toronto

We attached temperature-sensing radio transmitters to 3 males and 2 females in fall 2001, and 5 males and 1 female in January 2006. We collected data on emergence times, foraging and roost locations, roost characteristics and ambient/roost temperatures. Foraging occurred during nights throughout the winter, even with intermittent rain and cool (>4º C) temperatures. Roosts and nearly all foraging occurred within the riparian habitat. Males and females typically roosted together in a primary winter roost, the attic of a building located near a stream, but bats alternately used solitary satellite roosts all within the riparian zone and generally under the canopy. Bats switched roosts between the primary winter roost and their satellite roost, but did not share or switch satellite roosts. During an 11-day period, bats exited their roost intermittently (male mean emergence = once every 4.58 days, n = 5; female emergence = once every 1.38 days, n = 1). Winter day roosts were comprised of the attic of an unheated building; 6 riparian trees of 4 species (*Quercus lobata, Q. agrifolia, Umbellularia californica,* and *Platanus racemosa*) and 3 ground roosts (under a large rock, under a dry mop in a tool shed, and under a concrete outhouse foundation). Seven roosts were located within 250 m of the primary winter roost and 2 tree roosts were located about 2 km away. Temperatures of winter roosts were cooler and more evenly tempered than summer roosts. Both males and females had elevated skin temperatures in the primary winter roost on some nights that they did not exit. Males were reproductive October to January. Females left the winter roost and formed a maternity roost 2 km from the winter roost in mid-April.

Seasonal Changes in Thermal Conductance of Bat Pelage with Emphasis on the Eastern Red Bat (*Lasiurus borealis*)

Daniel J. Judy, Justin G. Boyles, George S. Bakken, and John O. Whitaker, Jr., Indiana State University, Terre Haute, IN

The eastern red bat (*Lasiurus borealis*) roosts in the foliage of trees during both summer and winter and has been observed hibernating under leaf litter during the winter. Therefore, they are likely more exposed to ambient conditions than many other mammals and they should have characteristics allowing them to maintain survivable body temperatures at low ambient temperatures. Conversely, in Indiana the big brown bat (*Eptesicus fuscus*) makes extensive use of buildings during both summer and winter and rarely experiences subfreezing ambient temperatures. Thus, the ecology of eastern red bats and big brown bats make for an intriguing comparison in terms of thermoregulatory studies. Understanding physiological and morphological aspects of these species may provide insights into whether roosting choices are ecologically or physiologically constrained. Knowing why and how species are capable of roosting in a particular area will allow conservationists to better identify areas in need of protection. We measured the thermal conductance of the dorsal fur excised from bats previously euthanized for rabies testing. Thermal conductance of pelage samples was measured on an electrically heated aluminum plate and a thin-film heat flow sensor at five wind speeds. Thus far, it appears there are seasonal differences in thermal conductance within species and between species, with lower thermal conductance values occurring in *L. borealis.*

Range-Wide Susceptibility of Priority 1 and 2 Indiana Bat Hibernacula to Land-Use and -Cover Change

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Summer maternity colonies of the migratory, federally endangered Indiana bat (*Myotis sodalis*) have been documented on eight Army installations and likely occur on many others. Unfortunately, little is known about the connectivity between Indiana bat summer and winter populations, including those that utilize maternity habitat on Army installations. Impacts on survival during migration, swarming, hibernation, and staging can have significant consequences for the viability of Indiana bat maternity populations. The extent to which hibernacula may be threatened by urbanization or other land-use and -cover change (LUCC) has not been previously investigated. Without information about the current condition or level of protection afforded to hibernacula, the effectiveness of species conservation, as well as Army investment in Indiana bat monitoring, management, and training mitigation, is potentially compromised. Several priority research needs identified by the USFWS Indiana Bat Recovery Plan are dependent upon the characterization of current and potential future land-cover near hibernacula. To investigate the susceptibility of priority 1 and 2 hibernacula (highest priority) to LUCC, we have initiated a range-wide, GIS-based analysis. Our characterization includes landscape, patch and class level metrics that describe habitat near Indiana bat hibernacula. Potential future risk of LUCC near hibernacula is being modeled from a diverse dataset of socioeconomic and biophysical variables. These characterizations and projections will advance discussion and consciousness regarding susceptibility of hibernacula systems, thereby helping to focus Indiana bat conservation efforts. This poster will present a summary of the approach and analyses.

Ultrasound Production by Non-Flying Bats

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Ultrasound is commonly used for orientation and prey localization by diverse taxa, including bats, odontocete whales, insectivores, and rodents. Ultrasonic signals in these groups range from simple broadband clicks to highly modified, tonal signals that show structured change over time. Most of what we know about the structure and function of ultrasound is based on studies of echolocation by microchiropteran bats and odontocete whales. There has been considerable research on the context of ultrasound production by muroid rodents (*Rattus* and *Mus*) in the laboratory, however, it is unclear if, and when, these sounds are produced in the wild, and how they function in natural habitats. By setting a dense grid of bat detectors on the ground, we made the first recordings of ultrasonic vocalizations produced by two free-living species of mice in the North American deer mouse genus *Peromyscus* (*P. californicus* and *P. boylii*) on long term study grids in California. The ultrasonic vocalizations we recorded represent 7 different motifs. Within each motif, there was considerable variation in the acoustic characteristics suggesting individual and contextual variation in the production of ultrasound by these species. We have also recorded ultrasound from wild *P. leucopus* in North Carolina and from captive *Peromyscus maniculatus, P. leucopus, P. californicus, P. aztecus, P. melanophrys,* and *P. eremicus* at the *Peromyscus* Stock Center. However, the repertoire of ultrasound motifs recorded from the stock center is more limited than the repertoire of ultrasound motifs recorded from the wild. The discovery of the regular production of ultrasonic vocalizations by *Peromyscus* in the wild highlights an underappreciated component in the behavior of these wild mice and an underappreciated source of ultrasound in the nocturnal acoustic landscape of North America.

Is Individual Identity Information Reliably Indicated in Sonar Calls of Little Brown Bats, *Myotis lucifugus*?

Karry A. Kazial and Sarah Pacheco, SUNY Fredonia, NY

We hypothesized that identity information is present in the calls of bats allowing for cooperation within colonies, location of roost sites, and recognition in mother-offspring reunions resulting in fitness benefits. We hypothesized that calls produced in flight would carry additional variation due to bats altering their calls related to changes in their distance to obstacles and stage of insect pursuit, decreasing the reliability of variation indicating the caller's identity. We were also interested in whether the same call descriptor variables indicating identity in one calling situation would do so in another. We obtained sonar calls from little brown bats captured from Chautauqua Institution and the SUNY Fredonia area. Calls were recorded while allowing bats to crawl from hand to hand and while in flight after release. The recording system included a laptop computer, digitizing card, amplifier, and U30 bat detector. Analyzed calls resulted in several variables that described each call. We examined signal consistency using reliability analysis and used discriminant function analysis (DFA) to assess classification success of calls to individual. Our analysis revealed that call variables had a very high level of repeatability indicating the presence of identity information for sonar calls produced within the same situation. DFA produced better than chance success for classification of calls to individual regardless of situation. DFA classification achieved best success within situation, even with a novel set of calls. Success was no better than chance when using the calls produced in one situation to classify calls produced in another. Therefore, variables that indicate individual identity information in one situation do not transfer well to the calls of the same bats produced in a different situation.

Impacts of Bt (*Bacillus thuringiensis*) Crops and Agricultural Pest Abundance on Bat Activity in South Texas Agroecosystems

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The widespread adoption of transgenic Bt (*Bacillus thuringiensis*) crops raises concerns that non-target species may be harmed and food webs disrupted. However, most studies of non-target effects of Bt crops focus on insect predators in controlled settings, and we know little about effects on higher-level predators in situ. This research is guided by two hypotheses: 1) The activity of Brazilian free-tailed bats (*Tadarida brasiliensis*) will track the availability of major insect pests in the agricultural region of South Central Texas, and 2) Bat activity will be reduced in Bt crops compared to conventional crops during local emergence of insect pests. To test these hypotheses, bat activity and insect activity were measured using a combination of ultrasonic monitoring, video imaging, and pheromone trap collecting in replicate Bt and conventional crops throughout the growing season. Preliminary results from Anabat II monitoring suggest that bat activity varies with farm location and time period, which may reflect variation in moth densities assessed by pheromone trap collections and distances to major roosts. Bat activity may also be negatively impacted by the presence of Bt crops at some sites during the peak emergence of moths from these fields, a time which coincides with high energetic demands for lactating bats. In addition to documenting the pest control services provided by bats, this study has conservation implications for bat populations already in decline. The results may extend beyond foraging bats in Texas, as the use of Bt crops in increasing throughout the U.S., and broader ecological impacts remain largely unknown.

Is Social Information Conveyed in the Sonar Calls of the Little Brown Bat, *Myotis lucifugus*?

Tammy L. Kenny, Karry A. Kazial, and Stephen C. Burnett, SUNY Fredonia, NY; Clayton State University Morrow, GA

The purpose of this study was to determine whether sonar calls can be used for social communication, specifically whether *Myotis lucifugus* can distinguish the gender, colony membership, and individual identity of a conspecific. Sonar call analysis of this species and others suggests that there may be variation found within calls to identify the above characteristics. Sonar calls were recorded during the summers of 2003-2005 at Chautauqua Institution, Chautauqua, NY. These calls were then played to bats captured from Chautauqua Institution and SUNY Fredonia. Sequences of 10 calls repeated for one minute were played from an ultrasonic speaker and the calling response of the test subject was obtained by a bat detector connected to a second laptop. Gender recognition involved playing a sequence of one gender on day one and then playing a sequence of the other gender two days later. The colony membership experiment was conducted in the same fashion except the call sequences were from a bat originating from the same colony as the test subject and an unfamiliar colony. Response for both experiments was measured as time to first call and call rate. Individual recognition was examined using a habituation-discrimination design. A call sequence from Bat A was played until the test subject's call rate decreased by 50%. Then either a new sequence from Bat A was played or a sequence from Bat B. Results will include an examination of time to first call, call rate, and time to habituate for subjects in all three experiments.

Spatio-temporal complexity of insectivorous bat assemblages from Malaysia: just what is a bat assemblage?

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The diversity of tropical bat assemblages is both a source of inspiration for community ecologists and, given the rapid loss of tropical habitats, a cause for concern for conservation biologists. Confounding both research foci are practical issues concerning the delineation of assemblages in both time and space. In this study, we used a standardized harp-trapping protocol to assess the spatio-temporal variability of insectivorous bat assemblages within contiguous, undisturbed lowland rainforest in Krau Wildlife Reserve, Malaysia. Total trap effort consisted of 5,974 harp-trap nights, distributed across five spatially independent sites and three temporal replicates, and generated just under 16,000 captures of 38 species from six families. Estimated species richness showed slight but significant differences across space and time, but spatio-temporal variability in the composition of the assemblages was pronounced, underpinned by complex and asynchronous interactions at the species level. At one extreme, capture indices indicate that a few species are consistently represented across spatial and temporal replicates. At the other extreme, several species showed substantial landscape-level variability, combined with patterns of temporal variability that were not consistent across spatial replicates. In addition, many species were characterized by intermediate patterns of spatio-temporal variability. As a result, assemblage structure was neither consistent across space nor stable over time. These findings have important consequences for our understanding of the processes determining assemblage structure, the design of diversity surveys, and the conservation of species-rich assemblages in the face of habitat disturbance and fragmentation.

A comparison of changes in wingloading associated with pregnancy in *Myotis evotis* and *M. volans*

Jessica Kiser and Rick A. Adams, University of Northern Colorado, Greeley, CO

Bats are able to forage in a wide variety of habitats. Wing loading affects flight speeds and maneuverability (turning radius) which is directly correlated with habitat use for foraging. Individuals with high wing loading usually have decreased maneuverability and therefore are usually open area foragers. Wing loading also varies with gestation in adult females. An increase in mass during gestation may affect the use of certain habitats and dietary composition. We compared pregnant female wing loading of two species: *Myotis evotis*, a clutter-area forager, and *M. volans*, a forest-edge 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 measurements. Wing area was divided into mass to determine the wing loading for each individual. Females of each species were categorized as pregnant or non-pregnant depending on reproductive state which was determined by abdominal palpation. One-way ANOVA was used to test for significant differences between wing loading for pregnant females of the two species. Results showed a significant difference between the wing loadings of pregnant *Myotis evotis* and pregnant *M. volans* ($p<0.001$). These results are consistent with foraging patterns. *Myotis evotis* is a clutter-area forager and therefore should have a lower mean wing loading ($x= 0.0022$ g/mm^2) than *M. volans*, a forest-edge forager ($x= 0.0029$ g/mm^2). Further research is being conducted to determine if diet is affected by changes in wing loading associated with pregnancy.

Understanding the Fall Migration of the Lesser Long-Nosed Bat (*Leptonycteris curasoae*): an Extension of the Arizona-Sonora Desert Museum's Migratory Pollinator Program (2-year project)

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In July and August 2004-2005, we marked 106 of the 206 lesser long-nosed bat (*Leptonycteris curasoae*) that we handled. We tested microchips (PIT Tags) as a marker and a new antenna design for detecting the microchips. The bats were marked at two maternity roosts in southwestern Arizona. We also placed radio transmitters on 22 bats and collected DNA (cheek samples) from 141 bats. We located three of the marked bats in southeastern Arizona. This is the first evidence that some of the *L. curasoae* are moving from the maternity roosts in the southwestern corner of the state to the mountains of southeastern Arizona before migrating to Mexico for the winter.

Ecological Impacts of Wind Power Development on Bats: Questions, Research Needs, and Hypotheses

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At a time of growing concern about the rising costs and long-term environmental impacts from the use of fossil fuels and nuclear power, wind power is a growing sector of the energy industry, largely because it has been promoted as being emission free and is supported by government subsidies. However, large numbers of bats are being killed at several utility-scale wind power facilities, especially in the eastern U.S., and these fatalities raise important concerns about population and cumulative impacts on bats. This paper briefly summarizes evidence of bat fatalities at wind power facilities in the U.S., identifies critical research needs, and proposes hypotheses needed to address these concerns to better inform researchers, developers, decision makers, and other stakeholders to help find ways to avoid, minimize, and mitigate impacts of wind energy facilities on bats.

Range Expansion and Changing Abundance of the Eastern Pipistrelle (*Pipistrellus subflavus*) in the Central Great Lakes Region

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Throughout northwestern Ohio, northern Indiana, southern Michigan, and western Ontario, only four records of the eastern pipistrelle (*Pipistrellus subflavus*) existed in the early 1980s. Most were adult males that were considered to be vagrants or disoriented migrants. Between 1993 and 2006, we gathered 69 additional records of this bat in the central Great Lakes basin, including reproductive females and young-of-the-year. Most were found near the eastern shore of Lake Michigan, particularly at two unusual hibernacula, Tippy Dam and Bear Cave. We speculated that modifications of Bear Cave associated with its commercialization in 1936-1940 paved the way for the eastern pipistrelle to colonize this area.

Things that Go Squeak in the Night: Atypical Biosonar Calls and Unusual Ultrasonic Sounds

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Biosonar calls of bats follow well described and predicable patterns, usually as frequency modulated or constant frequency calls in addition to occasional upward modulations. Social calls are highly variable in both structure and spectrum, but have been the subject of less study than biosonar calls. I have deployed automatic recording systems in the field as a part of local faunal surveys and in addition to the typical biosonar calls of bats, have recorded unusual bioacoustic signals that I cannot ascribe to a species. Sounds were recorded in three widely separated localities (central California, southern California and eastern France) in the spring and summer of 2006. I categorize these sounds as upwardly sweeping sounds, unusual low frequency calls and complex calls. Upwardly sweeping calls I have recorded are usually brief sounds (usually about 1 ms) and of low relative intensity. They can be low frequency, high frequency or broad band. Low frequency or broad band sounds are strong candidates for insect sounds, whereas calls of similar structure that extend above 100 kHz extend outside the range of frequencies to which most insects are sensitive. Some of the unusual low frequency calls are clearly bat biosonar calls. Their similarity to the calls of *Euderma maculatum*, would represent a range extension for the species. Another unusual bat call consisted of four short FM calls at low frequency in the midst of a series of typical search phase calls. The low frequency calls appear to be two harmonics below associated search phase calls. Another series of low frequency calls, however, are unlike any bat calls I have ever seen. These variable frequency calls in the range of 15-22 kHz frequently extend 300 ms in duration. Sounds that I categorize as complex calls probably represent social interactions at a feeding ground and are characterized by downward and upward frequency modulated sounds, often at a lower frequency than typical search phase calls. They typically come in the midst of search phase calls. Automated recording of ultrasonic signals provides a rich source of bioacoustic behavior that has gone unnoticed. Examination of these signals opens a window into the acoustic world that bats share with other animals.

Montserrat: Mist-netting bias and accumulation curves

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Mist netting is commonly used to capture bats but several studies have found that mist net capture data and methods are biased due to a wide range of factors and circumstances. Some of which include size and placement of nets, and the frequency at which investigators check their nets. Even though a plethora of literature and anecdotal reports are available, very few investigators have actually quantified the interactions of bats with mist nets directly. A recent exploration provided the impetus for use of night vision camcorders to re-evaluate the years of mist net data collected on Montserrat, Lesser Antilles. Many unique and interesting behaviors were observed in the bats approaching our mist nets. Observations were conducted on successive nights to see if there was any evidence of learning or avoidance. A total of 2,523 bat passes on 43.3 hours of tape were recorded in July 2005 and June 2006. When a mist net was present, only 5.4% of bats captured on film came into contact with the net, and the average capture rate was 4.2% (range 0–10.3). Obviously, mist nets are doing a very poor job of capturing bats that utilize flyways and thus generate potentially misleading data. Without consistent survey efforts and methods, biodiversity estimates and conservation guidelines based on mist net data cannot truly recognize the faunal diversity of an island.

Bats of the Canadian North: A survey of Nahanni National Park Reserve, Northwest Territories and surrounding areas

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I surveyed for bats within the South Nahanni River watershed and surrounding areas, Northwest Territories July –August 2006. Most of the survey took place within the current Nahanni National Park Reserve (NNPR) boundary. This was the first formal survey of bats in the NWT. Previous to this survey, 2 species of bats were known from the NNPR: *Myotis septentrionalis* and *M. lucifugus*. This survey confirmed the presence of these 2 species and added the following 5 bat species: *M. evotis, M. volans, Eptesicus fuscus, Lasiurus cinerus* and *Lasiurus borealis*. Four species were captured in mistnets (*M. septentrionalis, M. lucifugus, M. evotis* and *M. volans*), one species was detected acoustically with several visual identifications of bats in flight (*E. fuscus*), and 2 species were detected acoustically only (*L. cinereus, L. borealis*). After the survey period, a park employee reported seeing an "orange bat" near one of the locations where *L. borealis* was detected. Both sexes of bats were captured, but the only species found to be raising young in the park was *M. lucifugus*. Occurring north of 61^o latitude, this is the most northerly record of *M. evotis* and *M. volans* in North America. With 7 species of bats now known in the NWT, this territory has the greatest bat diversity in the North, followed by Alaska with 6 species. The year-round habitat usage of the bats in NNPR is not known and will require further study; however, that 7 bat species were found in the park increases the likelihood that parts of the entire watershed are important for bats and this should be taken into consideration in the park boundary expansion process that is currently underway.

Interbreeding of *Myotis lucifugus* subspecies in southern Alberta and north-central Montana

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Based on mitochondrial DNA sequences, two sympatric subspecies of *Myotis lucifugus* have been proposed on the Milk and Missouri Rivers of north-central Montana and southern AB: *M. l. carissima* and *M. l. lucifugus*. Are these sympatric subspecies biologically distinct, or is interbreeding occurring? To address this, we used both maternally inherited mtDNA sequence and biparentally inherited nuclear DNA microsatellite loci to understand both female and male genetic structure. We sequenced a hypervariable section (HVII) of the mtDNA control region and compared this with results from the cytochrome b and 16S ribosomal subunits used to genetically define and differentiate subspecies. We also genotyped each individual at 11 nuclear microsatellite loci. HVII haplotypes clustered into distinct groups that reflected the subspecies designations; this provides further evidence of distinct mtDNA differences within *M. lucifugus*. Because mtDNA is maternally inherited, we also analyzed nuclear microsatellite markers to determine whether breeding behaviour reflected these subspecies boundaries. Nuclear structure among the proposed subspecies categories was not found, suggesting that males and females of each 'subspecies' are interbreeding. Supporting this lack of subspecies division is the field observation that individuals of each 'subspecies' classification are mixed along the Milk and Missouri Rivers; for example, female *M. l. carissima* and *M. l. lucifugus* were found roosting together as one maternity colony in an attic roost on each river. We suggest that the proposed subspecies designations may reflect genetic drift that occurred during a past separation event but that interbreeding has and continues to be occurring among these groups, making subspecies designations unnecessary.

Bats and Bioluminescence in Fireflies: Aposematism or Pavlov's Bell?

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Fireflies (Coleoptera: Lampyridae) are chemically defended and their larval bioluminescence acts as an aposematic warning to some vertebrates. Although bats and fireflies co-occur in space and time, no study has investigated potential predation on adult fireflies by bats, including roles of toxins and bioluminescence in bat-firefly interactions. We (1) searched for published accounts of predation on fireflies by bats, (2) analyzed fecal pellets from sites where fireflies occurred (using a reference collection that included Lampyridae), (3) conducted controlled feeding experiments to determine palatability of fireflies to trained bats, and (4) flew untrained bats in an enclosure to quantify attacks on simulated fireflies of two sizes, with flashing and non-flashing light emitting diodes. Occurrence of lampyrids in diet of bats appeared only once in published literature. Likewise, fecal pellets from 63 *Eptesicus fuscus*, 75 *Myotis lucifugus*, 38 *M. leibii*, 14 *M. septentrionalis*, and 4 *Lasiurus borealis* contained no evidence of fireflies. A feeding experiment on 9 *E. fuscus* and 7 *M. lucifugus* resulted in 14 of 16 bats rejecting mealworms that were coated with homogenized fireflies. Limited investigation with 4 of these individuals suggested bats were willing to consume flashing mealworms. Preliminary results of experiments with untrained bats in a flight chamber suggest prey were attacked based on a combination of size and flashing cues. Results from flight chamber experiments with 35 bats (11 *E. fuscus*, 15 *M. lucifugus*, 8 *M. septentrionalis*, and 1 *L. borealis*) will be presented.

Bat Conservation in a Changing Landscape: The Role of Southeastern National Parks

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Development and urbanization in the southeastern U.S. are currently occurring at unprecedented rates, resulting in extensive forest loss and fragmentation. The greatest development is occurring in the Piedmont and Mountains of North Carolina, the Piedmont of South Carolina and Georgia, and in the coastal areas. This trend is predicted to continue for several decades. Thus, conservation of regional biodiversity may increasingly rely on parks and preserves, particularly in urban and suburban areas. During the summers of 2004-2006 I surveyed 10 National Park units in the Piedmont and Coastal Plains of North Carolina, South Carolina, and Georgia and tested the hypothesis that species richness, diversity, and evenness varied with park size and location (urban, suburban, or rural). Bats were sampled with mist-nets and Anabat II bat detectors. Species richness, diversity, and evenness did not vary with park size. Median species richness was similar in urban parks (S=5), suburban parks (S=6), and rural parks (S=3.5). In contrast, although not statistically significant, species diversity and species evenness tended be lower in urban parks (H'= 0.63, E=0.46) than in rural (H'=1.04, E=0.89) and suburban (H'=1.13, E=0.89) parks. This difference was due primarily to the dominance of big brown bats (*Eptesicus fuscus*) in the urban parks. Big brown bats made up a significantly greater proportion of captures in urban parks (78.1%) than in suburban and rural parks (22.1%). Further, big brown bats were recorded at significantly more acoustic sampling points in urban parks (64.0%) than in rural parks (13.0%). These data suggest that urban parks may be important refuges for a number of bat species, particularly those that do not adapt well to urban environments. However, urbanization appears to have a significant effect on community structure.

Diet of Mexican Free-tailed Bat in Southern Mexico with Special Reference to the Fall Armyworm a Corn Pest

Leonardo J. López and Rodrigo A. Medellín, UNAM, México, D.F. México

Diet of Mexican Free-Tailed Bat (*Tadarida brasiliensis mexicana*) in the south-central United States has been widely described. It was also demonstrated that the seasonal pattern of insect consumption is closely correlated to patterns of emergence, migration and availability of adult populations of corn earworms (*Helicoverpa zea*) and fall armyworms (*Spodoptera frugiperda*), both species of noctuid moths and major crop pests. In Mexico, emergences of corn pest moth populations coincide with the spatio-temporal distribution of *T. b. mexicana*, suggesting that the described bat-pest link extends to the complete distribution of this subspecies. San Francisco Cave, at La Trinitaria Municipality, Chiapas, México, was visited monthly to sample individuals from each of the two foraging bouts. Diet composition is being determined by fecal analysis. In this study 327 fecal samples (133 males, 138 females) were analyzed. Thirteen orders and 22 families were identified, documenting this bat diet in a year from December 2004 to December 2005. Major items are represented by the orders: Lepidoptera (59%), Coleoptera (13%), Hemiptera (4%), Hymenoptera (2%), Diptera (1%) and Neuroptera (1%). The proportion of lepidopterans in the sample coincides with the emergency peaks of the fall armyworm (*Spodoptera frugiperda*; the main corn pest in Mesoamerica) described for the region, one from January to March and the other from August to December.

Daily and Seasonal Patterns of Bat Activity along Central Appalachian Ridges

Keith D. Lott and J. Edward Gates. University of Maryland, Frostburg, MD

In 2003-2004 high numbers of bat fatalities were documented during post-construction mortality surveys at two wind turbine facilities in the Appalachian Mountains of West Virginia and Pennsylvania. Between 38 and 25 bat fatalities per turbine were observed, making them the highest fatalities ever recorded at wind turbine facilities. In addition, mortalities were generally limited to an 8-week period in the fall coinciding with bat migration. The timing and number of mortalities in the aforementioned surveys raised the preliminary issues of whether bat activity increases in the fall and whether it varies among ridge sites; this possibility is particularly important in the Appalachians, where additional wind turbine facilities have been proposed. To address these questions, we attached Anabat II acoustic monitoring equipment to several tall towers within Maryland, Pennsylvania, and West Virginia in an attempt to examine inter-ridge variability and to determine how weather, time of year, and moon phase may affect above canopy bat activity. Echolocation calls were recorded from 1900-0700 h nightly from mid-April until mid-December. The number of calls per night was compared to data from the nearest Department of Transportation weather station. Initial results suggested that temperature is highly correlated with bat activity. Wind speed, precipitation, and humidity also influenced activity, though to a lesser extent. Wind direction and moon phase showed no relationship. Monthly comparisons found no significant differences in activity from June-October. Sites in the Ridge and Valley province generally had higher activity than those on the Appalachian Plateau.

Although more research is needed, these results have important implications for the placement and management of future wind turbine facilities within the Appalachians.

Summer Roost Trees of Rafinesque's Big-eared Bats in Congaree National Park

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The Congaree National Park contains the largest remaining tract of old-growth bottomland forest in the US and its many large, hollow trees provide prime natural roosting habitat for Rafinesque's big-eared bats (*Corynorhinus rafinesquii*). The objectives of this study were to determine the roost tree characteristics of big-eared bats in this optimal habitat and determine whether roost tree characteristics differed between maternity groups and males. Using mist and hand nets, Rafinesque's big-eared bats were captured and fitted with 0.46g transmitters (LB-2N, Holohill Systems). Tagged bats were tracked to 22 day roosts throughout the park. For each roost tree we recorded species, decomposition state, DBH, tree height, location of cavities, cavity dimensions (when possible), and cavity orientation. Rafinesque's big-eared bats roosted in 4 tree species: *Nyssa aquatica* (n=18), *Nyssa sylvatica* (n=2), *Taxodium distichum* (n=1) and *Liquidambar styraciflua* (n=1). Male roosts (n=15) did not differ significantly from maternity roosts (n=7) in tree height, DBH, cavity opening width, cavity opening height, decomposition state, tree species, or cavity orientation; both maternity and male roosts were typically located in bottomland hardwood forest. However, location of the roost cavity (basal or upper bole) differed significantly between males and maternity colonies. Maternity roosts were typically in upper boles (85.7%) and male roosts in basal cavities (93.3%). Maternity groups may choose upper bole cavities because of their added predator protection. While this study supports previous studies that have found this species using both basal and upper bole cavities, it also provides more specific information on the individuals using these types of roosts.

Automated Extraction of Echolocation Calls from Broadband Digital Recordings

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Bat sonar researchers can now easily record extended broadband digital files encompassing the full sonar spectrum, each potentially containing hundreds of calls. The massive amount of data that arises can easily preclude manual extraction (by either spectrogram or playback); thus, an automated, computer-based solution is needed but not trivial to create. The goals of an extraction program depend on the research objectives, while the problems the program must solve depend on the recording conditions. Differing objectives and recording conditions preclude a one-size-fits-all program. For instance, one researcher might wish to locate every sonar call, no matter the species, while another might be interested in a single species. Likewise, one researcher might wish to count every recognizable echolocation call, while another might wish to extract only “good” calls suitable for further analysis and ignore those with small amplitude, contaminating reverberations (echoes), or obscuring sounds from other bats or insects. Depending on the recording situation, the goals of these researchers might be either more or less easily satisfied (e.g., only one bat with no contaminating sounds vs. numerous bats with background insects and echoes). We describe here a call extraction program, part of a suite of open-source programs called EARS (Echolocation Analysis and Recording Software), written in an established high-level engineering and signal-processing language (Matlab). To address the problem of varying objectives and situations, the user can customize extraction to a certain extent by setting the values of important parameters (e.g., upper and lower cut-off frequencies, threshold criteria, etc.). In addition, knowledgeable users can create new functions or extraction criteria. We hope users who create useful new routines will add them to EARS.

Interleukin-2 Expression in Big Brown and Mexican Free-tailed Bats

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As part of a larger study to assess immunocompetence in big brown bats and free tailed bats and relate this capacity to susceptibility to rabies, we have begun to characterize the cytokine response (specifically, interleukin-2 (IL-2) and interleukin-13, to assess T and B cell activation, respectively) in these species. However, very little is known about the immune response in bats in general and there is no documented gene sequence of any of the bat interleukins. Using GenBank, we compared IL-2 gene sequences from 16 different mammalian species and found several regions that were 78-80% conserved. Using these conserved areas, we designed several degenerate forward and reverse primers for use with RT-PCR. Using Concavalin A (ConA-50ug/ml), a T cell mitogen, we stimulated the production of IL-2 in 200 ul whole blood samples (1:10 dilution) from big brown bats and free tailed bats which were then incubated for 1 hour at 41°C. Control blood samples were run concurrently. We extracted RNA, ran RT-PCR, and the resulting cDNA was placed on 1% agarose gel. Resulting bands were sequenced and found to be IL-2. Big brown bat and free-tailed bat sequences most closely resembled those found in *Homo sapiens*. We found wider bands in samples that had been stimulated by con-A but also observed IL-2 bands in unstimulated samples. We are now developing a quantitative RT-PCR assay. In a separate study, we injected the same dose of Con-A in vivo in big brown bats, collected a blood sample 24 hours after injection, and, using a commercial human IL-2 ELISA kit, were able to quantify circulating levels of IL-2 protein. We are in the process of validating the use of this kit.

Possible Historic Changes in Relative Use of Natural and Anthropogenic Roosts by the Mexican Free-tailed Bat (*Tadarida brasiliensis*)

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Mexican free-tailed bat (*Tadarida brasiliensis*) populations have historically experienced sharp declines in natural cave roosts because of physical and ecological disturbances such as guano mining, pesticide poisoning, and cave tours. The principal objective of this project is to evaluate the probable significance of anthropogenic structures in an historical context for *T. brasiliensis*. We hypothesize that, because natural roosts are limited in number and space, the anthropogenic segment of the population has increased in proportion to the availability of anthropogenic roosts decade by decade. Moreover, natural and anthropogenic roosts often show different usage patterns in relation to seasonality, with several anthropogenic roosts providing adequate winter roosting conditions. We are relating our roost-use findings to human population growth, highway and overpass construction, and environmental factors to chronologically “map” the hypothesized pattern. Archival records, including newspapers, journals and oral histories, naturalists’ papers, county extension records, faunal surveys, and museum specimens were examined. Local residents and officials were consulted, and field work is being conducted at current roost sites, both natural and anthropogenic, throughout the research area to determine population structure and the nature of roost use (nursery, bachelor, and transient). We are seeing anthropogenic sites located near natural cave roosts. In addition, we have recorded *T. brasiliensis* over-wintering in at least two central Texas anthropogenic structures, and are currently collecting records to evaluate the possibility that overwintering characterizes anthropogenic roosts in the same areas where natural roosts are not occupied during winter. The majority of anthropogenic structures in our research area are not used as nursery sites, although most of natural roosts do serve as shelter during pup-rearing.

A Genetic Analysis of the Fission-Fusion Roosting Behavior of Tree-Roosting Maternity Colonies of Big Brown Bats (*Eptesicus fuscus*)

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In Cypress Hills Interprovincial Park, Saskatchewan, tree-roosting big brown bats (*Eptesicus fuscus*) exhibit fission-fusion behavior and roost in 3 non-overlapping roosting areas (RA1, RA2, RA3). The resident group of about 30 female adults is loyal to the same roosting area within and between seasons. Although bats switch roost trees and potentially roost-mates about every two days, roosting associations between pairs of *E. fuscus* are nonrandom. To understand if genetic relationships mediate fission-fusion behavior in tree-roosting bats, we combined genetic analyses with behavioral studies. First, we determined if related and/or matrilineal females prefer to roost with one another. Second, we determined the amount of gene flow between roost areas. Genetic relationships and gene flow were inferred from nine microsatellite loci and from a segment of the mitochondrial DNA control region. Roosting associations were determined from two sources: (1) a pairwise sharing index based on radiotracked bats from 2000-2002, and (2) roost-tree trapping events that occurred from 2002-2005. Gene flow was determined from pairwise F_{st} and Φ_{st}. Roosting associations were not influenced by relatedness or matrilineal relationships. Female-mediated gene flow was restricted between RA1 and RA2 ($\Phi_{st} = 0.145$) while male-mediated gene flow was not ($F_{st} = 0.015$). Despite female philopatry and preferred roost-mates, roost-mate decisions are not based on genetic relationships. Thus, kin selection is not likely to occur at roost sites. Instead, the fission-fusion system is probably maintained because of individual benefits, separate from kin selection, gained through close associations with preferred roost-mates (e.g., information transfer, allogrooming) and membership to the same group (e.g., cumulative knowledge of suitable roost and foraging sites, thermoregulation).

Roosting Ecology and Emergence Times of the ‘Ōpe ‘ape ‘a on the Island of Hawaii

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We present a qualitative description of the day and night roosts used by the Hawaiian hoary bat (*Lasuirus cinereus semotis*), known to Hawaiians as the ‘ōpe ‘ape ‘a . We captured bats along roads and flyways of exotic, urban, and native landscapes using elevated mist nets. We followed bats (N = 18) to tree roosts using radio-telemetry and attempted to visually confirm the location of roosting bats. Bats captured in urban and exotic plant dominated landscapes commonly selected roosts in exotic trees including *Eucalyptus* spp., *Mangifera* sp., *Litchi* sp., *Persea* sp., and *Albizzia* sp. The native tree 'ohi'a-lehua (*Metrosideros polymorpha*) was used by four bats captured in native forest, and one bat captured in an urban landscape. Roosts were located within or under dense vegetation, but had an open access point to facilitate launching into flight. Bats selected roosts in sub-canopy if canopy trees had sparse foliage, and dominant canopy trees where dense foliage was present (e.g. 'ohi'a-lehua forest). During the period of lactation, we observed bats roosting in groups ≤3, likely representing mother-offspring groups. We monitored the evening emergence of bats from roosts both visually and by telemetry. Emergence time of females was 9.3 ± 8.4 (mean ± se) min before sunset whereas male emergence was 10.3 ± 2.7 min after sunset. Night roosts used by the ʻōpe ʻape ʻa included their day-roosts or a variety of trees near foraging locations including the genera *Eucalyptus*, *Macadamia*, and *Araucaria*. Roosting position was often <5 m above the ground when roosting in *Macadamia* or *Araucaria*, but >5 m when in *Eucalyptus*.

Genetic Variation and Population Genetic Structure of Townsend's big-eared bat (*Corynorhinus townsendii*) in Southeast Idaho

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Townsend's big-eared bats hibernate in large numbers in the lava tube caves of the Snake River Plain of Southeast Idaho. The Snake River Plain was not glaciated during the Pleistocene and may represent one of the northern-most extents of the historic range of this species. If southeastern Idaho has been long-occupied by this species, we would expect to find a genetic pattern of isolation by distance among populations accompanied by high levels of variation comparable to more southerly distributed populations. In order to test this prediction, we genotyped 88 individuals from seven hibernacula on the Upper Snake River Plain using five polymorphic microsatellite loci. We find that genetic diversity across these populations is comparable to more southerly distributed populations with a range of 6-19 alleles per locus and average heterozygosity of 0.5972. However, our analyses of population genetic structure suggest that the majority of variation is apportioned within populations with very low subdivision among populations and no evidence of an isolation by distance pattern. The lack of isolation by distance suggests that this region may have been relatively recently colonized but that the colonization process captured a broad range of genetic diversity maintained in more southerly distributed areas. Our ongoing analyses of mitochondrial diversity as well as increased spatial sampling will allow us to further refine our understanding of the biogeographic history of this taxon as well as identify the spatial extent of genetic subdivision.

Predicting *Desmodus* range extension as a response to climate change

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One of the major impacts of global climate change is the shift of species range. While there is evidence that some species are already changing their distributions due to climate change, predicting how species will react in the future is considerably more difficult. Here we present an analysis of the possible northward range expansion of *Desmodus rotundus* by modeling potential changes in temperature gradients in Mexico and the U.S. during the next 75 years. *Desmodus* presents a unique case for the study of response to climate change because vampire bats have strict physiological limitations on the amount of energy available for maintaining body temperature. These limitations include the inability to maintain an adequate metabolic rate when the ambient temperature falls below 10ºC. The northern limit of the distribution of the vampire bats is thus postulated to be correlated with the winter 10ºC isotherm. With current trends in global warming, the region that encompasses the border between Mexico and the U.S. is predicted to increase in temperature by 1.0 to 3.0 degrees. We use current climate models to show the potential movement of the 10ºC isotherm significantly to the north, particularly along the east and west coasts of Mexico, Baja California as well as the southern tip and Gulf Coast of Texas. *Desmodus* range size is predicted to increase by at least a third of its current range and will occupy almost the entire southern and coastal regions of Mexico.

Innate and Adaptive Immune Function in the Big Brown Bat, *Eptesicus fuscus*

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Innate and adaptive immune function provide vertebrates with an assembly of mechanisms used in response to invading pathogens, and the relative strength of these arms of the immune system affect how animals respond physiologically to exposure and infection. The aim of this study is to characterize the relative strengths of innate and adaptive, specifically cell-mediated, immune responses in the big brown bat, *Eptesicus fuscus*, and how these responses may relate to population or life history differences and pathogen exposure. Bats were captured from 10 barns located in southern New Hampshire and eastern Massachusetts. To measure the innate immune response, blood samples were used in a bacterial killing assay in which whole blood was diluted, mixed and incubated with a standard concentration of *Escherichia coli*. Bactericidal ability of blood was determined by comparing bacterial colony counts on agar plates spread with blood/bacteria mixture to those spread only with bacteria. To assess the cell-mediated response, bats were injected subcutaneously with phytohaemagluttinin (PHA), a known T-cell mitogen. Indices of response were calculated using measurements of swelling at sites of injection compared to measurements at sites of control injections. Contrary to predictions, preliminary results suggest that bactericidal ability and response to PHA challenge did not differ significantly by sex, age, reproductive status, or location. These results may be due to small sample size or other biases in sampling. By examining relative immune strength of bats living in different habitats, we can better understand how various factors, such as reproductive stage, sex, age, and location possibly influence the ability for bats to respond immunologically when confronted with invading pathogens.

Diet of Eastern Small-Footed Bats (*Myotis leibii*) in New Hampshire: Evidence of Gleaning?

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Little is known about foraging ecology of eastern small-footed bats (*Myotis leibii*). Descriptions of foraging behavior are limited to anecdote and foraging strategy only has been hypothesized using wing morphology and echolocation characteristics. Because published information about the diet of *M. leibii* does not exist, we studied food habits of 36 *M. leibii* captured in southern New Hampshire, from 14 May to 30 August, 2005 and 2006. Fecal contents were identified to lowest possible taxonomic level using a reference collection of arthropods from New England. Food habits of *M. leibii* were compared to those of 63 *Eptesicus fuscus*, 75 *M. lucifugus*, and 14 *M. septentrionalis* that co-occurred with M. *leibii*. Preliminary analysis of

18 *M. leibii* samples documented > 6 arthropod orders, with Diptera (44.6% ± 8.9%), Lepidoptera (24.8% ± 8.3%), Coleoptera (14.1% ± 6.3%), and Arachnida (9.4% ± 6.7%) forming greatest percents by volume (mean ± SE). Simple matching coefficients suggest the diet was most similar to that of *M. septentrionalis*, a species known to hawk aerially in cluttered space and glean prey from surfaces. This suggests that *M. leibii* uses similar foraging techniques. Analysis of remaining *M. leibii* fecal samples (n = 38) will be presented.

Use of Forest Edges by Bats in a Managed Pine Forest in Coastal North Carolina

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Bats are a primary component of the pine forest food web. There are 12.9 million ha of intensively managed pine forests in the southeastern U.S. which results in modifications of the landscape including mosaic patterning of heterogeneous forest patches and an increase in amount of forest edges. Our objective was to investigate foraging behavior of bats within an intensively managed pine landscape in coastal North Carolina. We sampled bat community structure, foraging activity, diet, and insect distribution in four structurally distinct forest types (young open-canopy pine, pre-thinned pine, thinned pine, and unmanaged forest) and along forest edges during summer 2006. At each sampling site, from dusk until dawn, we used two Pettersson D240X bat detectors (one real-time mode and one time-expanded mode) with digital recording units to record echolocation calls. We used real-time recordings to quantify bat foraging activity, and time-expanded recordings to identify bat species. We opportunistically used mist netting to obtain reference echolocation calls and fecal samples for bat diet analysis. At each site, we also indexed the insect community using passive malaise insect traps. We used chi-squared statistics to compare bat and insect community structure across stand types and detect trends in prey selection. We used regression models to compare bat foraging behavior between forest types and edges, and examine relations between insect distribution and bat foraging behavior. Preliminary results suggest that inducing edges in a managed pine forest landscape may result in shifts in bat community composition. For example, *Eptesicus fuscus* were recorded primarily along edges whereas *Myotis* spp. were detected only in forest interiors.

*Constraints and coevolution in an extremely specialized bat-flower mutualism

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*** Nathan Muchhala** received the **Luis F. Bacardi Bat Conservation Award** (Lubee)

Some of the most compelling evidence for coevolution comes from the tight morphological match between extremely long-tongued animals and the flowers they pollinate. Classic examples include giant hawkmoths and the Malagasy Star Orchid, and sword-billed hummingbirds and *Passiflora mixta*. Extreme lengths are thought to occur via a ‘race’ between pollinators and flowers; however, such tight coevolution requires a high degree of specificity in the interaction and could be halted by evolutionary constraints on either mutualistic partner. For flower-visiting bats, relatively low evolutionary plasticity in mouthpart morphology appears to have constrained coevolution, and resulted in non-specific, diffuse interactions between bats and the flowers they pollinate. Here I combine ecological and morphological studies to document a spectacular exception: a recently discovered species of bat (*Anoura fistulata*) that has evolved a tongue which can protrude twice as long as its congeners (longer, relative to body length, than any other mammal), and serves as the exclusive pollinator of a plant (*Centropogon nigricans*) with flowers of matching length. Comparison with other bats reveals unique adaptations in tongue morphology which allow *A. fistulata* to circumvent functional constraints that normally limit tongue extension. The highly specialized mutualism between *A. fistulata* and *C. nigricans* provides a striking case study of the interplay of coevolution and constraints which shape the evolution of pollination systems.

Green or Not – Bat Fur Can Host Symbiotic Algae

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Greenish colored bats collected from Papua New Guinea have been found to obtain their green color from symbiotic algae growing in their fur – attached to the surface of hairs of *Dobsonia*, within the hollow hair shafts of *Nyctimene*, and growing within the hollow hairs of non-green *Syconycteris*. These findings, based on iodine-based starch tests and phase contrast microscopy, were presented previously at these meetings by the second author. Our continued research aims to better characterize the algae involved in these relationships and to investigate the prevalence of such associations between algae and bats. We have obtained fresh fur samples from species of bats housed at the Lubee Bat Conservancy, Gainesville, FL, and inoculated flasks of algae-growth medium to culture the associated algae. We used scanning-electron microscopy and digital phase-contrast microscopy with these fresh cultures to identify the algae based on morphology. We have also extracted algal genomic DNA from the cultures and sequenced nuclear and chloroplast rDNA to compare with published sequences to more precisely identify the algal species. We have found that many of the bats from which we received hair samples have started colonies of different species of green and blue-green algae in the algal growth medium, though the bats' fur is not usually green. Our results suggest that associated algae may be quite common in bat fur, though in some species it may not normally grow densely enough to affect the overall fur color. Our investigations will continue as we refine our techniques to deal with smaller samples of algae, and obtain samples from more bat species.

Roosting Ecology of the Evening Bat (*Nycticeius humeralis*) at the Northern Edge of its Range

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Although common in the Southeast, evening bats (*Nycticeius humeralis*) were not known to reside as far north as the Great Lakes region until the discovery of a maternity colony in 2004 in Lenawee County, Michigan. In 2006, we began a study of this colony, the northernmost colony for the species, and obtained preliminary data on roost-tree selection and inter-roost movement. We mist-netted bats from 20 May to 23 August 2006 within the floodplain of the River Raisin, Black Creek, and Bear Creek and placed radio transmitters on 20 adult and juvenile evening bats. We confirmed 20 roost trees by radiotracking each bat daily and observing evening emergence. Nineteen of 20 roost trees were found in bottomland forest, and the bats roosted primarily in living green ash (*Fraxinus pennsylvanica*) and snags of unknown species. Mean height of tree was 23 ± 8 m (SD; n = 20) and mean diameter was 59 ± 23 cm (SD; n = 20). Bats roosted in cavities (45%), cracks (27%), and under exfoliating bark (27%). Evening bats used cavities and exfoliating bark during all reproductive stages; however, pregnant bats did not roost in cracks. Evening bats switched roosts every 1.3 days, with pregnant females switching less often than lactating and post-lactating females. Studying the roosting ecology of the evening bat in southeastern Michigan will provide insight as to how a southern species copes with life on the northern edge of its range.

Phylogenetic and Ecological Structuring in a Paleotropical Bat Assemblage

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With the recent explosion of molecular phylogenetic studies, there has been increased interest in how phylogenetic relationships among species relate to patterns of community structure. Due to shared evolutionary histories, closely related species are predicted to have similarities in ecological characteristics, termed niche conservatism. In sympatry, however, interspecific interactions may cause ecological differentiation, or niche shifts, between closely related species and may weaken the relationship between phylogenic relatedness and ecological similarity. Currently, there is little consensus in the role competition plays in structuring bat assemblages and essentially nothing is known about the role of phylogenetic relatedness. Thus, I examined eco-morphology and echolocation of 15 species of hipposiderid bats in Krau Wildlife Reserve to investigate whether this group exhibited nonrandom ecological or phylogenetic structure. Bats were captured in harp traps along trails and in caves, lengths of forearm, tibia, tail and ears were measured, and wing biopsies were taken. Time expanded echolocation calls of hand-held bats were recorded and the peak frequency was determined. Skulls were removed from voucher specimens and measured, and wing morphology was measured from digital photographs of bats with their right wing extended. DNA was extracted from wing biopsies and a 500bp section of the mitochondrial ND2 gene was amplified and sequenced. Phylogenetic hypotheses were estimated using both parsimony and bayesian analyses, which produced similar trees. The guild of hipposiderid bats was not distributed randomly in multivariate space. The results suggest that sister species are morphologically more divergent than expected at random. Interestingly, some distantly related species pairs are closer in morphology than expected at random.

The Role of Frugivorous Bats in Tropical Succession

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Discussion of successional change has traditionally focused on plants. The role of animals in producing and responding to successional change has received far less attention. Dispersal of plant propagules by animals is a fundamental part of successional change in the tropics. We review patterns of seed dispersal by frugivorous bats with the aim of describing their role in successional change in tropical forests. We explore the similarities and differences of this ecological service provided by New and Old World seed-dispersing bats, and conclude with a discussion of current conservation implications. Our review suggests that frugivorous New World phyllostomid bats play a more important role in early plant succession than their Old World pteropodid counterparts. We propose that a longer evolutionary history with small-seeded early successional shrubs and treelets in phyllostomid bats than in pteropodid bats, which are principally dispersers of the seeds of canopy fruits, explains this difference. Despite these differences, fruit-eating bats play important roles in forest regeneration throughout the tropics.

Pattern of Activity of Cave-Dwelling *Artibeus jamaicensis* in the West Indies

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The pattern of activity of the Jamaican Fruit Bat (*Artibeus jamaicensis*) roosting in a cave in Puerto Rico, West Indies, was observed using a Sony Digital 450 infrared video camera. Activity was assessed filming a cluster of bats continuously over 24 h periods. Recordings were observed later and activity categorized as: “flying”, “grooming”, “active”, or “at rest”. Most bats were absent from the cluster from sunset through sunrise, although around midnight 10% to 20% of the individuals returned to the day roosting site for a period of two to three hours. Immediately after their return to the roost at dawn, bats spent most time “at rest”. Bat activity inside the cave increased around noon and most “grooming” activity began in the hours prior to evening departure from the roost.

*Habitat selection as a mechanism of resource partitioning in two cryptic bat species: *Pipistrellus pipistrellus* and *Pipistrellus pygmaeus*

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* **Barry Nicholls** received the **Bat Conservation International Award**

The recent separation of a common Palaearctic bat, the pipistrelle, into *Pipistrellus pipistrellu*s and P. *pygmaeus*, which are sympatrically distributed throughout their range, raises the question as to whether these two morphologically similar species partition resources in time and space. The present study used radio telemetry to address the spatial distribution, habitat preferences and foraging characteristics of *P. pipistrellus* and *P. pygmaeus* in northeast Scotland. We reveal large and significant differences in the spatial distribution and foraging characteristics of these two cryptic species. Individual *P. pipistrellus* home ranges were on average three times larger than that of *P. pygmaeus*, and they foraged for approximately an hour longer each night. Inter-specific spatial overlap was minimal (<5%) and core foraging areas of either species were essentially mutually exclusive despite the proximity of the two roosts. The two species showed distinct habitat partitioning with *P. pygmaeus* foraging predominantly in riparian woodland and over water, and *P. pipistrellus* foraging along woodland edges and short isolated tree lines. We predict that niche partitioning in these species is a result of selection favoring the avoidance of inter-specific competition through differential habitat use.

Multi-Scale Selection of Roosts by Northern Long-Eared Bats

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Studies in eastern North America have shown that northern long-eared bats (*Myotis septentrionalis*) are selective in their choice of day roosts, but roost, stand, and landscape characteristics vary among study areas. Our primary objective was to identify multi-scale factors that affect summer roost selection of northern long-eared bats in the southern Appalachian Mountains where they have not yet been studied. We radio-tracked 12 females and 10 males daily to roosts until transmitters were recovered or the signal was lost. Characteristics of roost (n=64) and random trees and the surrounding habitat (0.04-ha plots) were measured and compared. Tree and plot variables did not vary significantly between male and female roosts.

Several characteristics distinguished roost trees from random trees ($P < 0.05$). Roosts had lower midstory cover at the roost entrance height and less remaining bark. When compared with random trees, roosts were closer to dead or damaged trees and the 0.04-ha plots contained a higher basal area of dead or damaged trees. Roosts were mainly in oaks, black locusts, or dogwoods and exclusively in live-damaged or dead trees. When compared to random points on the landscape, roosts were closer to roads and perennial streams. In the southern Appalachian Mountains, northern long-eared bats appear to select roosts for traits that minimize energetic costs, regardless of gender. Low midstory cover would simplify emergence from the roost and minimize predation risk, while selection of roosts near other dead or damaged trees may facilitate switching in the event of a disturbance. Roosting near corridors such as roads and streams may minimize the cost of commuting to foraging areas.

Sensory Mode Switching in Prey Detection by the Frog-Eating Bat, *Trachops cirrhosus*

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The fringe-lipped bat, *Trachops cirrhosus*, is unique among bats in its ability to exploit frog mating calls to find its prey. In addition to passively listening for prey-emitted cues, *T. cirrhosus* produces echolocation calls as it approaches its target. In this study we asked: to what degree do *T. cirrhosus* rely on passive versus active acoustic cues, and further, can they switch sensory strategies in response to foraging success? We presented wild-caught bats with a speaker concealed underneath a smooth 1.5 x 1.5 m screen. We broadcast frog calls from the speaker, and placed an anesthetized frog on the screen 30 cm from the speaker. We recorded whether the bats approached the frog calls (the speaker) or the actual frog. In all initial trials, bats flew directly to the speaker and were unsuccessful in locating the frog. We then tested to see whether the bats could switch sensory modes in response to capture success, and learn to weigh echolocation cues more heavily than passive acoustic cues. In a series of conditioning steps, we rewarded responses to active localization of prey. We then retested the same bats, and found the opposite result. The bats did not land on the speaker, and were successful in capturing the silent, motionless frogs that were displaced from the sound source. We compared approach behavior and echolocation sequences. The fringe-lipped bat, *T. cirrhosus*, relies most heavily on prey-emitted cues in its localization of prey, but it is flexible in its ability to switch sensory strategies in response to foraging success, and can rapidly adjust its use of specific sensory cues with experience.

Multivariate morphological analysis of niche partitioning among Costa Rican bats

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The notion of "ecological niche" has been defined a variety of ways; a significant one is as a multi-dimensional hypervolume constituted by factors influencing an animal's environment and behavior. This concept of a niche may be approximated from a morphological perspective by measuring morphological features, thereby visualizing how animals in a community partition multivariate niche space. Bats are ideal organisms to study interspecific niche partitioning for several reasons: Chiroptera is the second largest order of mammals; they exhibit almost every feeding mode known among mammals; and many seemingly similar species are found together in the tropics. Costa Rica is an exceptional location for ecological research on bats because of its diverse habitats, extensive network of national parks, and large body of work already conducted, translating to extensive materials at hand in collections. In this study, I quantified the ecological niches of Costa Rican bats using multivariate statistical analyses of 76 cranial and skeletal measurements. Measurements were taken using digital calipers from skins and skulls of specimens preserved in natural history museums. Data were analyzed using principal component analysis to visualize niche partitioning within the bat community and assess niche breadth and overlap. I predicted that there would be little overlap among species and that all of the multivariate morphological space would be optimally occupied: that is, maximal utilization of morphological multivariate niche space will lead to little or no overlap among species, but high density of those species present. My data to date do in fact support this hypothesis. These ecomorphological data suggest that bats divide niche space, hence use their habitat, extremely finely, potentially leading to extensive and strong interactions at the community level.

Dietary Analysis of *Myotis evotis, M. thysandoes*, and *M. volans* in Boulder County, CO

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Bats can eat a diverse range of insects and most appear to be flexible in their diets. There are several species of insectivorous bats that utilize the same habitats for foraging and many species feed on the same type of insects. Three species that have been previously found to feed on the same type of insects are *Myotis evotis, M. thysandoes,* and *M. volans. Myotis evotis* mainly feeds on beetles but will also feed on moths and caddisflies. *Myotis thysandoes* has a broad diet consisting of moths, beetles, caddisflies, bees, and wasps. *Myotis volans* generally feeds on moths but will take smaller insects as well. To our knowledge, the diets of these species have not been recently compared in Boulder County. We compared the diets of *Myotis evotis, M. thysandoes,* and *M. volans* to determine if they were consuming the same types of prey. Bats were captured using mist nets at six water holes in the foothills of Boulder County, Colorado from May to September 2004. Guano samples were collected and taken back to the lab for analyses. Guano bolices were separated by using Whitaker's methods. Insect parts were separated out and identified to order using several insect keys and references. Percentage of total diet for each *Myotis* species was calculated for each of the identified orders. All three species' diets mainly consisted of moths and beetles however the range of insect orders consumed by bats varied greatly by species.

Effects of Landscape Structure and Composition on Roost Selection by Forest Bats

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Although information exists on relationships between forest microhabitat and selection of roosts by forest-dwelling bats, little is known regarding effects of landscape arrangement on roost selection. We evaluated effects of topographic features (elevation, slope, and proximity of roads and streams), forest habitat class, and landscape (patch configuration) on selection of summer roosts by 6 species of forest bats in a diverse forested landscape of west-central Arkansas to determine which attributes of landscapes were important in predicting occurrence of bat roosts. We modeled roost selection at 2 spatial extents to determine if the effects of landscape attributes were resilient to changes in spatial scale. In general, small-extent (a 250-m radius) models of landscape attributes associated with roost selection were a better fit than large-extent

(1,000-m radius) models. For most of the 6 species, forest habitat class was included more often than patch configuration or topography in differentiating roost from random locations, regardless of extent. Topographic features were included in models more often than patch-configuration metrics. Most species roosted in areas that contained substantial amounts of recently thinned forest that retained a component of mature overstory trees. At both extents, eastern red bats (*Lasiurus borealis*) were more likely to roost in close proximity to roads, whereas eastern pipistrelles (*Pipistrellus subflavus*) were more likely to roost further from roads than random. Big brown bats (*Eptesicus fuscus*) and Seminole bats (*Lasiurus seminolus*) roosted closer to riparian areas than random at both scales.

Population Genetic Study of *Desmodus Rotundus* in an Area of High Bat Rabies Incidence in Cattle, San Luis Potosí State, Mexico

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In the eastern portion of the state of San Luis Potosí, Mexico, bat rabies in cattle has increased significantly since 2001. The cases in this area and neighboring states account for 60% of the reported bat rabies in cattle in Mexico. In 2005, an albino *Desmodus rotundus* was captured in Tamasopo, San Luis Potosí, Mexico. At this time color variants of yellow and orange *D. rotundus* were also identified. We are pursuing a fine-scale, population-level genetic analyses of *D. rotundus* in eastern San Luis Potosí to determine if there is a relationship between the high incidence of rabies in this area and the appearance of recessive traits in these bats. This is a portion of an international multi-agency collaboration to support the Mexico/U.S. bi-national agreements of monitoring and surveillance for wildlife diseases.

Intraspecific Variation in the Echolocation Calls of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*)

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The Hawaiian hoary bat (*Lasiurus cinereus semotus*) is the only known extant bat species found in the Hawaiian archipelago. This makes it an ideal species to study acoustically in that overlap in call characteristics between species resulting in misidentification is not a factor. The purpose of this study was to assess the intraspecific variation in the echolocation calls of the Hawaiian hoary bat, specifically examining differences in echolocation call characteristics between locations, as well as within and between individuals. Using an Avisoft recording system, I recorded free flying bats from six locations at weekly or bi-weekly intervals from May through August, 2006, on the Big Island of Hawaii. I also used radio-telemetry to record the echolocation calls of known individuals as a way to assess intra-individual variation. Preliminary results suggest that echolocation call sequences may be accurately classified to location and in some cases, individuals.

Stereoscopic Reconstruction of Flight Paths of Foraging Bats Using Multiple Thermal Infrared Cameras

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To study the foraging behavior of bats, including the Brazilian free-tailed bat (*Tadarida brasiliensis*), we took infrared thermal videos of bats during warm weather nights in south-central Texas and used computer vision techniques to detect and track the bats. We recorded bats foraging over a small body of water adjacent to a corn field from which moths were emerging. Three different cameras, approximately 20 meters apart, were used to take simultaneous videos of this scene for the purpose of reconstructing the 3-Dimensional (3D) trajectories of the bats. Our computer vision system implements an automatic, adaptive thresholding detection algorithm and a Kalman filter is used for tracking. To aid in the calibration of the cameras, we used heat producing calibration devices that we designed, constructed, and installed in the field of view. Once the camera system was spatially calibrated and synchronized in time, we projected from each camera center through the image of the bat in the 2D image plane and then used triangulation to obtain the 3D coordinate of a foraging bat for each instance in time. Analysis of corresponding video frames recorded by the three cameras then produced the reconstructed 3D trajectory of the bat.

Craseonycteris thonglongyai: One Species or Two?

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Recent surveys in Myanmar documented for the first time the presence of the Bumble bee bat, *Craseonycteris thonglongyai*, outside the Kanchanaburi region in Thailand, doubling its distribution range. Individuals discovered in Myanmar were morphologically indistinguishable from Thai individuals although their echolocation call peak frequency was 8-10 kHz higher. This high difference in echolocation was unusual for populations of the same species that are distant by only 200 km. These findings raised important questions about the possible presence of cryptic species and the validity of echolocation call variation to define species or sub-species boundaries. In April 2006, we recorded *Craseonycteris thonglongyai* echolocation calls from different caves throughout its entire known distribution range in Thailand and Myanmar. At the same time, DNA was collected either from biopsy punch or droppings. Sequences from three mitochondrial fragments (partial Cytochrome b, tRNA-Thr and partial control region) were analyzed to determine the relationships between individuals from different localities. This was compared with the echolocation call frequency data and geographic distribution.

Can Radar Deter Bats from Wind Farms?

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At present, there are no direct methods for preventing collisions between bats and the blades of wind turbines. The suggestion that bats avoid radar arose from the observation of a student returning from field work, with a bat detector wedged in the window of his car, that no bat passes were heard in the vicinity of the Aberdeen airport radar. A short research project subsequently recorded bat passes automatically at two airport radars, with two sites matched for altitude and land use. Significantly fewer passes were recorded in the vicinity of the radar installations. In order to increase this data base, five civil airport air traffic control (ATC) radar stations, three military ATC radars and four weather radars were selected. Each was surrounded by heterogeneous habitat. At each radar station three sampling points were chosen along an electromagnetic gradient within a habitat category likely to be suitable for bats. Each sampling point was matched for habitat type and structure, dominant vegetation species, connectivity, altitude and surrounding land class. Each successive sampling point was located at increasing distance from the radar station and subject to differing levels of electromagnetic radiation. A portable electromagnetic field meter (PMM 8053-Accelonix Ltd.) was used to measure the field strength of the radar at three distances from the radar source. At each sampling point, bat activity was recorded from sunset to sunrise using an automatic bat recording station. A 30 min transect was carried out at each site using a frequency division bat detector to allow species identification. Each of twelve radar station sites were surveyed during summer 2006 three times at three independent sampling points, resulting in a total of 108 samples, 36 within each field strength category.

Radiative and convective heat flux from Brazilian free-tailed bats, *Tadarida brasiliensis* in flight

Jonathan Reichard, Boston University, Boston, MA

In bats and birds, only 5-20% of metabolic output during powered flight is converted into mechanical power, while the remainder is dissipated in the form of heat. Heat dissipation by radiation, convection, and evaporation is important in avoiding hyperthermia during these periods. Models describing metabolic and mechanical power in flight indicate the body temperature (Tb) of *Tadarida brasiliensis* (mean body mass = 11.35 g), should produce 1.92 J s^{-1}, resulting in an increase of 1ºC in Tb over about 24 seconds in the absence of heat dissipation vectors. However, internal Tb in free-ranging *T. brasiliensis* decreased by a mean 2.3ºC, from 36.8ºC to 34.4ºC over 3-5 hour foraging bouts. This heat loss is equivalent to 108.8 J net transfer from the bat over the flight period. Surface temperatures measured by infrared thermography were used to determine radiative and convective heat fluxes from free-ranging bats during emergence and return flights at a maternity colony in south-central Texas. Heat radiated from the body, head, wings, and uropatagium at mean rates of 16.3 ± 4.8, 13.5 ± 3.7, 6.4 ± 10.5, 2.8 ± 2.2 J s^{-1} m-2. The same surfaces contributed convective fluxes of 110.9 ± 34.0, 92.4 ± 26.2, 33.4 ± 27.1, and 90.3 ± 148.2 J s^{-1} m^{-2}, respectively, to total heat flux from the body. Since evaporative cooling occurs at the expense of body water, it may not be viable as a major thermoregulatory mechanism for organisms living in hot, arid habitats. By revealing large surfaces during flight, bats achieve increased radiative and convective heat transfer to thermoregulate with minimal water loss.

Species Richness and Structure of Three Phyllostomid Bat Assemblages

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We compare the assemblages of phyllostomid bats of three Neotropical rainforests and suggest a method to validate estimates of species richness for Neotropical bat assemblages based on mist-netting data. The fully inventoried bat assemblage at La Selva Biological Station (LS, 100 m NN) in Costa Rica was used as a reference site to evaluate various estimators of species richness. The Jackknife 2 method agreed best with the known bat species richness and thus was used for extrapolation of species richness for an Amazonian bat assemblage (Tiputini Biodiversity Station, TBS, 200 m NN) and an Andean pre-montane bat assemblage (Podocarpus National Park, BOM, 1000 m NN) in Ecuador. Our results suggest that more than 100 bat species live sympatrically at TBS and about 50 bat species coexist at BOM. TBS harbors one of the most species-rich bat assemblages known, including a highly diverse phyllostomid assemblage (Shannon diversity index: 3.04). Taxonomic diversity within the phyllostomid family was high at all sites (FLS = 2.59, FTBS = 2.65, FBOM = 2.51). Our analysis of assemblage structure of the three phyllostomid assemblages reflects differences in patterns of floral radiation. At the Andean site, where understory shrubs and epiphytes have undergone the largest radiation, the phyllostomid assemblage was mainly composed of understory frugivores and nectarivorous species. By contrast, the Amazonian site was dominated by canopy frugivores, coinciding with the radiation of canopy fruiting trees in the Amazon basin. Assemblage patterns of other taxonomic groups may very likely reflect the radiation of floral elements in the Andean and Amazonian regions.

Assessing Stress in Bats Using Fecal Cortisol Assays

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Chronic stress in mammals is associated with elevated daily secretion of glucocorticoids. In bats, the major glucocorticoid is cortisol. Cortisol is a critical hormone that affects most organ systems and physiological processes. However, chronically elevated cortisol leads to immuno-suppression with increased incidence of metabolic disturbances, cardiovascular changes, and infertility. Certain stimuli ('stressors') appear to be ubiquitously stressful in mammals. These include stimuli like audible noise and seismic vibration, which are commonly encountered near military bases at which training exercises are routinely performed. We are investigating the long-term consequences of chronic exposure of endangered Indiana bats (*Myotis sodalis*) to activities associated with training and operations at nearby military bases. Fecal assays have been developed as an indirect means of assessing stress in free-ranging or endangered mammals, without the requirement for invasive procedures or blood sampling. While most of the circulating glucocorticoids in mammals are excreted in the urine, a small percentage of cortisol appears in the feces in proportion to plasma concentrations. As part of developing this assay for *M. sodalis*, we collected fecal samples from an abundant related (non-endangered) species, the little brown bat (*Myotis lucifugus*), which serves as a surrogate species. We have been able to detect immuno-reactive cortisol in extracts of fecal samples taken from *M. lucifugus*. We are now: 1) determining the minimal amount of fecal sample required to detect fecal cortisol; 2) assessing degradation of a sample’s cortisol over the course of an entire collection period; and 3) examining effects of different fecal storage methods on fecal cortisol levels.

Oh what a feeling: landing on a ceiling!

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Because bats roost head-under-heels, but cannot hover in that position, landing on a ceiling presents a biomechanical challenge. For a flying bat to attach its feet to a ceiling, it must impart to its center of mass enough rotational momentum to bring the feet above the head, sufficient vertical momentum to bring its feet into contact with the ceiling, but avoid hitting the roof so hard as to suffer injury. In August 2005, we used high-speed video and a ceiling-mounted force plate to record the landing performance of 8 Jamaican Fruit Bats (*Artibeus jamaicensis*) at the Montréal Biodôme in Canada. Our goals were to (1) describe the kinematics of body rotation as bats approached the ceiling, (2) measure the magnitude of compression force exerted by the hindlimbs of bats on the ceiling, and (3) measure changes in the position and velocity of the center of mass with respect to the ceiling during landing. The magnitudes of landing forces (toward the ceiling) in all 54 trials were <50% of body weight, indicating that bats land relatively gently. In the single trial where the bat landed making contact with only the plate, we found that the center of mass was lifted 2.5 cm higher during approach than its final resting position 7.3 cm from the plate. This strategy increased the amount of time available for attachment of the hindlimbs than would be available if bats brought the body only as high as its final resting position.

Winter Captures and Roost Selection of Silver-haired Bats (*Lasionycteris noctivagans*) in Missouri

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Silver-haired bats (*Lasionycteris noctivagans*) are exceedingly uncommon in summer bat surveys in Missouri and none were captured during the two winters preceding our first capture. As part of a study on the winter ecology of bats in Missouri, we captured 17 silver-haired bats during the fall and winters of 2004-05 and 2005-06, with captures in every month from September through March. Two males were found on the ground in Springfield, and the others were netted over streams and service roads in forested areas. Adult males and females were captured both years. During the winter of 2005-06, we placed radio transmitters on 4 males and 2 females and tracked them to a total of 13 roost trees, all oaks. Mean diameter at breast height (48.9 cm) and height (21.8 m) of roost trees was significantly different from 25 random trees (20.4 cm and 14.0 m, respectively). One roost tree was a snag with numerous cavities and loose bark and 12 were live trees with visible cavities or crevices. Weight of 4 females averaged 12.9 g (range 11.5 - 15 g) and 6 males averaged 10.3 g (range 9.5 - 11 g). Fecal analysis from two males captured in January and February indicated that these bats are feeding on three orders of flying insects as well as non-volant larval insects. It is unknown if these recent captures are related to warmer winter conditions or lack of netting in the same locations.

Digital Image Processing of Thermal Infrared Videography for Automated Detection and Tracking of Bats in Flight

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Thermal infrared imaging systems have proven useful for non-invasive detection and monitoring of wildlife at stand-off distances. Under many thermal conditions animals are readily detectable because warm, exposed portions of the animal contrast with the colder, adjacent background scene. Most previous work with thermal infrared imaging has relied on human interpreters for detection of the target animals. This can be a tedious and subjective process. A technique is described for automatically detecting, tracking, and enumerating free flying bats, imaged with thermal infrared videography, using digital image processing software. The basics of this technology are described and test case results are presented and compared with simultaneous results from older established techniques. While this work focuses on bats, the capability developed is generic and may have applications to other wildlife study scenarios.

*Diet of the Threatened, Migratory Mexican Long-nosed Bat *Leptonycteris nivalis* in a Mating Roost in Mexico

Ragde Sánchez, UNAM, México

*** Ragde Sánchez** was the first recipient of the **Bernardo Villa Award**

Leptonycteris nivalis is a migratory nectarivorous bat that is under protection in the U.S. and Mexico, and considered endangered by IUCN. The scarce available information about its diet has been collected in the northern part of its distribution, but in the south and center nearly nothing is known on foraging habits. I studied *L. nivalis* in the Cueva del Diablo, Mexico, the only mating roost known for the species. My goals were: to document the diet of *L. nivalis* during their seasonal stay in the cave; to record temporal changes in the use of food plant species during the mating season; and to test whether there are dietary differences between sexes. I used palynological analysis on fur and fecal samples for plant identification, and Chi-square tests with Yates' correction to determine significant differences in the use of plant species and diet between the sexes. I found insect fragments and pollen from ten plant species, belonging to five families: Cactaceae (*Stenocereus beneckei*), Bombacaceae (*Ceiba aesculifolia, Pseudobombax ellipticum*), Convolvulaceae (*Ipomoea arborescens*), Fabaceae (*Calliandra houstoniana, Bauhinia ungulata*) and Amaryllidaceae (*Agave dasylirioides, A. horrida, A. inaequidens, A. salmiana*). Bat diet was most diverse in November. I found no significant differences between the diet of males and females. Of the four Agave species I found, two have paniculate inflorescences that are commonly associated with bat pollination, while the other two had spicate inflorescences, which are considered insect-pollinated. Some of the plant species I found have special conservation needs in Mexico. This information allows us to gain a wider perspective about the relevance of the vegetation type and area size that need to be preserved for the purpose of recovering this species.

Bite Force and Feeding Behavior in Phyllostomine Bats: basal Patterns within the Phyllostomidae

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Phyllostomid bats are widely recognized for showing a great diversity of feeding specializations. In addition to ancestral insectivory, their feeding habits include frugivory, carnivory, nectarivory, sanguivory and omnivory. Members of phyllostomid clades are characterized by similar feeding specializations. Among these, the Phyllostominae, a subfamily with relatively primitive morphology and predominantly insectivorous diet, always occupies basal positions with respect to groups with more derived feeding habits and morphologies, such as the frugivores. These characteristics make phyllostomines an excellent system for studying transitional stages in the evolution of feeding habits that derived from insectivory in phyllostomids. Although correlations between phyllostomid cranial morphology and feeding habits have been shown, little is known about the evolution of interactions between morphology and feeding performance, much less in phyllostomines. These associations are probably key factors in niche partitioning and diversification among all phyllostomid bats. Here, we compare the feeding performance and feeding behavior of phyllostomid bats from four subfamilies, including phyllostomines. We measured feeding performance as the maximum forces produced during four bite types (canine unilateral, canine bilateral, molar unilateral, molar bilateral), and quantified the feeding behavior in terms of the proportions of these same bite types used while ingesting prey items. Our results indicate that maximum bite force increases from anterior to posterior bite points along the tooth row in all species, and the differences between unilateral vs. bilateral bite forces becomes apparent only in specialized frugivores (stenodermatines). We will make comparisons among these patterns of bite force production, and briefly explore how these feeding performance variables relate to cranial morphology, feeding behavior and, ultimately, the evolution of feeding habits in phyllostomids.

Detection of Fire by Eastern Red Bats (*Lasiurus borealis*): Arousal from Torpor

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Red bats (*Lasiurus borealis*) have been found in torpor under leaf litter during cold weather. Torpor, by its very definition, prevents a bat from moving quickly if disturbed; however, red bats have been observed on numerous occasions coming out of the leaf litter during cold-weather fires. Unfortunately they have also been observed injured or dead after a fire has passed. The presence of bats in the leaf litter can be a problem for wildlife managers who often use prescribed burns as a forest management tool, especially in the winter and early spring. The objective of this study was to determine factors that may trigger red bats to arouse from torpor during a burn. Red bats were tested separately in an environmental chamber and subjected to three treatments and controls. Latency time to arousal as effected by smoke, fire sound, and a combination of both was tested in the lab. Red bats (n=15) responded and aroused from torpor when subjected to smoke, but did not arouse to the sound of fire alone. However, the shortest latency period to response and arousal was to a combination of smoke and the sound of fire. No responses were observed during the controls. These responses will be discussed in the context of red bat winter ecology and the results may help forest managers to determine optimal burning conditions that are less likely to negatively affect red bat populations.

Influence of a Waterproofing Modification to Anabat II Acoustic Detectors on Bat Activity and Species Identification Studies in Three Different Habitats

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Several different waterproofing modifications have been developed for acoustical monitoring equipment such as the Anabat II detector. The use of transducers placed in PVC tubing and angled downward towards a reflective plate (a.k.a. "bat-hat") provides protection from rain, but the influence of such modifications on bat activity and species identification studies has not been reported. We simultaneously recorded bat echolocation calls with Anabat II detectors that were modified with bat-hats and those that were unmodified in three different habitats (open field, closed canopy-forest, and forest edge). Our preliminary analysis included seven nights of sampling and compared the total number of call sequences with ≥ one pulse and the total number of search-phase calls with ≥ five pulses recorded by each system. The mean number of calls recorded were lower with bat-hats in all habitats (field 5.43 SE 1.49, forest 4.71 SE 0.99; and edge 144.1 SE 45.3) than without bat-hats (field 9.43 SE 3.32, forest 7.86 SE 1.42, and edge 195.9 SE 55.5). Similarly, search-phase call sequences recorded with a bat-hat were lower in all three habitats (field 0.143 SE 0.143, forest 0.286 SE 0.184, and edge 31.6 SE 9.6) than without a bat-hat (field 1.286 SE 0.565, forest 1.857 SE 0.884, and edge 123.7 SE 33.4). The low number of calls recorded in the field and forest compared to along the edge, may explain differences in number of search-phase calls recorded in these habitat types. Our preliminary results suggest that equipment modifications and associated bias should be considered when designing acoustical monitoring studies.

Preliminary Study: Seasonal and Sex Differences in Immunocompetence in Hibernating Big Brown Bats

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There is little known about the consequences of hibernation on immunocompetence in vertebrates. The immune system is known to be sensitive and responsive to environmental changes as well as hormonal and nutritional factors. We conducted a preliminary study on the seasonal changes in immune responsiveness in a captive colony of male and female big brown bats (*Eptesicus fuscus*). From 2002-2003, the bats were housed in environmental chambers that allowed us to alter the temperature and photoperiod. Bats were kept on a natural photoperiod cycle. During Dec – March, bats experienced alternating periods of 5 degrees C for 7 days and then 22 degrees C for 5 days. This manipulation mimicked the natural cycle of torpor and arousal found in bats in the southeastern US. We used two assays to access immune response. Phytohemagglutinin (PHA) skin test was used to assess T-cell responsiveness and sheep red blood cells (SRBC) were used to assess B-cell responsiveness. The assays were administered before and during the torpor period. There were no significant differences in the T-cell response between the seasons or the sexes. We did observe significant differences in B-cell response: before hibernation females responded faster then males while during hibernation, males responded faster then females. Both sexes had a higher peak response in non-hibernating then hibernating conditions.

Forelimb Morphology of Scaly-tailed Squirrels (Anomaluridae): convergence with Bat and Dermopteran Hindlimbs

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Anomalurids (three genera and seven species) are commonly known as scaly-tailed squirrels. These rodents inhabit tropical and subtropical forests in western and central Africa. Bearing superficial resemblance to gliding squirrels (Sciuridae), gliding phalangers (Marsupialia: Petauridae), and calugos (Dermoptera: Cynocephalidae), they have been placed into the Suborder Anomaluromorpha with springhares (Pedetidae). All but one anomalurid (*Zenkerella insignis*) has evolved the ability to glide, and like other mammalian gliders, the lift-generating surface is provided by folds of skin between the head and wrist (propatagium), and between the wrist and hindlimb (plagiopatagium). As in calugos and many bats, a well-developed uropatagium is also present between the hindlimbs. Unique to gliding anomalurids, however, is a long strut (roughly the length of the forearm) extending from the posterior aspect of the elbow to the anterior border of the plagiopatagium. This ‘styliform cartilage’ resembles the chiropteran calcar and uropatagial spur, hindlimb structures involved in supporting and changing the shape of the uropatagium in micro and megachiropterans, respectively. Similarities in digital morphology were also noted between the forelimb claws of two anomalurids (*Anomalurus* and *Idiurus*) and the hindlimb claws of bats. Finally, tendon locking mechanisms, present in forelimb digits of gliding anomalurids, are similar to those seen in the hindlimbs of bats and dermopterans. In each case, structural adaptations exist that allow digital flexor tendons to interlock with the cuff-like retinacula that overlay them. Presumably forelimb adaptations in anomalurids function in gliding, climbing and hanging.

Bat Guilds in Tropical Forest and Agro-pastoral Habitats on Mount Isarog, Philippines

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Tropical landscapes, once covered in structurally complex forests, are being rapidly reduced and converted into more structurally simple habitats. Moreover, land conversion has resulted in the redistribution of food resources, particularly aquatic-borne insects provided by intact streams. In this study, I tested whether Philippine bat guilds, defined by their diet and their ability to utilize microhabitats that vary in structural clutter, were influenced predictably by loss of habitat complexity and aquatic subsidies. I sampled bat guilds using mist nets, harp traps and a tunnel trap, at three elevations, on two sides of Mount Isarog (Luzon Id.). The montane and lowland forests on the south side were highly disturbed and those on the west side were largely intact. Mossy forest on both sides was virtually untouched. A total of five frugivore species (N = 245), 10 background clutter insectivores (N = 187) and 11 high clutter insectivores (N = 165) were documented. Given equal sampling effort, species accumulated at an equal rate on both sides in mossy forest, but more quickly in the intact forest at the mid- and low elevation sites. High clutter insectivores and background clutter insectivores were more species-rich and more abundant in intact than disturbed forest at the mid-elevation sites. In mossy forest, background clutter insectivores were abundant on the south side where the streams were water-filled, and virtually absent on the west side where stream beds were dry. While the distribution of bat guilds was partially explained by existing habitat structure, this study suggests that for some species (e.g., *Hipposideros ater*, *Myotis horsfieldii*) other factors, such as roost sites and aquatic resources, may take precedent over forest cover when assessing the conservation “value” of an area.

Intraspecific Variation in Echolocation Call Structure of Philippine rhinolophids and hipposiderids

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Degree of isolation and subsequent divergence among populations can be illuminated by comparing echolocation call structure. Such characterization is also necessary for accurate acoustic monitoring. We tested for sexual and population differences in call attributes (duration, peak frequency, initial and terminal frequency modulation) within 10 constant frequency (CF) bat species inhabiting three mountains (Makiling, Banahaw and Isarog) on Luzon Island, Philippines. Captured bats were recorded in hand using a time-expansion ultrasonic detector and the calls were analyzed using Avisoft SASLab Pro software. The call structures of two cryptic *Rhinolophus* species (*R. arcuatus* and *R. new sp.*, in prep), which co-occur on Mt. Banahaw, did not differ significantly. *Rhinolophus arcuatus* females exhibited a higher mean peak frequency than males on Mt. Isarog, but not on Mt. Banahaw. Moreover, the mean peak frequency of *R. arcuatus* calls from Mt. Banahaw was significantly lower than those recorded on Mt. Isarog. In contrast, *R. inops* and *R. virgo* call attributes did not vary significantly across sites. Lastly, while low sample sizes prohibited statistical testing, mean peak frequency of *Hipposideros obscurus* calls recorded on Mt. Banahaw were lower than those recorded on Makiling. These results suggest that cryptic bat species can have similar call structures, and that further morphological and genetic analysis of species exhibiting geographic call variation may reveal multiple species complexes in the Philippines.

Bats of Morgan-Monroe and Yellowood State Forests, Indiana

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This summer we surveyed two state forests (Morgan-Monroe and Yellowood) in Indiana for bats. We netted a total of 18 sites twice. Each site included 4 multi-tiered mist-nets arranged to maximize bat captures. We captured the following six species of bats: northern myotis (*Myotis septentrionalis*), eastern red bats (*Lasiurus borealis*), big brown bats (*Eptesicus fuscus*), Indiana myotis (*Myotis sodalis*), little brown myotis (*Myotis lucifugus*), and eastern pipistrelles (*Perimyotis subflavus*). Once we complete collection of this preliminary data, areas within each forest will be harvested using a combination of even-age, uneven age, and strict preservation approaches. We hope these experimental harvests will provide managers with an understanding of which management techniques allow the state forest system to continue to harvest timber and regenerate forests for future uses while providing summer roosting and foraging habitat for the endangered Indiana myotis.

Defining emergent properties from ecologically complex and scale dependent habitat associations of Townsend's big-eared bat

Richard E. Sherwin, Christopher Newport University, Newport News, VA

While it is generally understood that organisms have clear associations with specific habitat features, the degree of expression of these associations varies across spatial and temporal scales. The potential for spatio-temporal scale dependency makes it extremely difficult to assign biological significance to observed patterns collected at small spatial scales or over short temporal periods. Over the past 10 years my research has focused on understanding the habitat and roosting affinities of Townsend's big-eared bat in the western United States. While patterns of landscape level use have slowly become apparent, it is only recently that we have begun to understand how local patterns reflect emergent properties of the entire system. These findings suggest that this system is much more plastic than has been previously supposed and that current assumptions regarding habitat and roosting associations are not entirely accurate. In particular, assumptions of system stability expressed by high roost fidelity and local scales of activity are far too simplistic. Unfortunately, current management models are largely based on these assumptions. While abandoned mines and caves provide tremendous ecological gravity within landscapes, individuals and colonies flow among groups and features in dynamic, yet stable patterns. In this presentation I will discuss the emergent properties of this system and the direct implications that these have for the management and conservation of Townsend's big-eared bats in the western United States.

The Influence of Water Quality on Dietary Patterns of Piedmont Bats as Determined by Stable 13C and 15N Isotope Analysis

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Urbanization can decrease water quality and impact stream biotic abundance and diversity. Stream communities provide basal resources for higher trophic level organisms. In the United Kingdom and North Carolina, bat species distribution varies with water quality and foraging activity is low downstream of pollutant inputs. Bats are a major predator of stream insects and possibly good terrestrial indicators of the effects water quality has on stream ecosystem function. The purpose of our study was to determine how water quality influences bat diet in a system affected by wastewater treatment plant (WWTP) effluent. The natural abundance of stable isotopes 13C and 15N were used to determine 1) the enrichment in insects and bats upstream and downstream of a WWTP and a pristine reference site, and 2) link trophic levels of insects and bats. Additionally, we compared stable isotope analysis to standard bat fecal analysis to compare methods. We captured bats and insects upstream and downstream of a WWTP in the Piedmont of North Carolina and at the nearby Uwharrie National Forest. Bat hair and whole insects were dried, homogenized, and analyzed for natural abundance of stable isotopes. Preliminary results exclude certain insect orders, such as Orthoptera and Hemiptera, as dietary items for bats and confirm bats as top predators on both first and second order consumers. *Lasiurus seminolus* are lower order consumers than all other bat species present. *Nycticeius humeralis* and *Lasiurus borealis* have consistently high 15N enrichment signals regardless of water quality whereas *Eptescus fuscus* 15N enrichment varies with water quality. The utility of natural abundance of stable isotopes for examining bat insect food web appears promising.

Using Ultrasonic Call Characteristics to Acoustically Differentiate *Leptonycteris curasoae*

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Many species of bats can be identified by their ultrasonic calls. Inventory for bats by this manner greatly increases the capability to locate bats in far wider landscapes or inaccessible situations than has been accomplished by traditional netting methods. More importantly, using ultrasonic calls for identification and inventory allows less disturbance of bats than traditional methods. There has been a need for dependable ultrasonic call identification for endangered lesser long-nosed bats in Arizona. We used both frequency division (Anabat) and time expansion (Pettersson D240x) sonar detectors to actively and passively record ultrasonic calls of *Leptonycteris curasoae* and *Choeronycteris mexicana* in situations where we had visually identified the bats. We recorded calls of the individual species from hand-released bats or as they exited from known roosts, while they fed at agave flowers and hummingbird feeders, or where they hung in buildings. Bats were netted at feeders, agaves, and a bridge night roost. We did not disturb bats in natural day roosts. We identified bats in the hand or in still photos and video recordings as we simultaneously recorded calls using time-synchronized multiple detectors and video cameras. Using calls only from identified individuals, we employed Anabat, AnaPocket, AnaLook, and Bat Sound Pro software to analyze calls. We tabulated call characteristics to define species calls that allow observers to differentiate *L. curasoae* from other species of bats in Arizona. Similarly, we recorded and analyzed ultrasonic calls of *C. mexicana* to allow observers to distinguish these sympatric nectar-feeding species. These techniques can be used to help land managers inventory for endangered *L. curasoae* without impacting bats.

Roosting Habits and Uses of Natural Rock Features by Townsend's Big Eared Bats (*Corynorhinus townsendii*) in Nevada

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We documented the roosting preferences of *Corynorhinus townsendii* in Pershing County, Nevada between the months of May and mid-August 2006. Twenty five bats were fitted with transmitters (8 adult males, 16 adult females, 1 young of year male, and 1 young of year female). Roosts were located during the day and data loggers (Hobos H8 and H10, Onset Computer Corporation) were installed on or near the location of bats at 13 roost sites. We located a total of 41 day roosts that included abandoned mines and epigeic features; including rock crevices, rock faces, and natural grottos. Bats frequently moved amongst roosts and roost types with no apparent association to specific climatic conditions. While some bats traveled as far as 17 km between roosts, they typically stayed within a 2.5 km radius of the previous nights roost. Reuse of epigeic roosts was rare. However, reuse of subterranean habitat was common amongst individuals from colonies. The percentage of transmittered bats from subterranean colonies found roosting on the surface on any given day typically ranged between 10% and 50%. Daily mean temperatures of diurnal roosts differed on average by 4.8 degrees Fahrenheit during periods of survey. This evidence suggests that *C. townsendii* are more opportunistic in their use of day roosts than has been previously supposed.

Analysis of echolocation variations affecting Doppler shift compensation

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Echolocation calls vary for a variety of reasons, as seen prominently among the search, approach, and terminal phases of foraging. A recently proposed theory states that call variation arises in part to compensate for two sources of cross-correlation errors between transmitted and received echolocation calls: 1) transmission-reception displacement error, εt; and 2) Doppler-shift error, εD. Cross correlation is used to estimate the time delay between transmission and reception of a call, and the time delay is used to estimate distance to a target. The actual time delay, Δt (zero velocity), and the perceived time delay, Δtx (from cross correlation), are related: Δt = Δtx- εt + εD. If a bat is moving towards a target, εt increases as target distance and flight speed increase while εD increases only as flight speed increases due to the Doppler effect. For a given flight speed and call shape, there is one distance at which εt = εD, called the distance of focus (DOF). We investigated the properties of calls that affect DOF by analyzing chirp signals, and we compared the theoretic results with real echolocation calls from a variety of species. DOF decreased as signal bandwidth increased and ranged from a few cm to more than 6 m. We found that a complex relationship exists between Doppler-shifted calls and the cross-correlation function, which made accurate estimates of εD difficult. Real calls included variable amplitude modulation, echoes, and noise which further confounded accurate estimates of εD. We conclude that the DOF theory is currently limited by the difficulty in estimating εD using cross correlation.

Responses in the Lab of *Eptesicus fuscus* to an Acoustic Deterrent Device

Genevieve R. Spanjer, University of Maryland, College Park, MD

Bats sometimes suffer fatalities as a result of contact with wind turbine blades. As a result, efforts are underway to discourage bats from coming near the turbines. Many bat species are very sensitive to ultrasonic noise, and such noise may “jam” their echolocation. I tested the response of bats to a cylindrical device containing eight speakers pointing outward emitting white noise at frequencies from 12.5 to 112.5 kHz at about 100 dB SPL per speaker at 1 meter. Bats were tested in feeding or non-feeding trials with the acoustic deterrent device in four quadrants in a flight chamber. In half the trials, the acoustic deterrent broadcast signals and in half the trials, the device was silent. Bats in feeding trials were presented with a tethered mealworm in the same quadrant as the device. In non-feeding trials, bats landed in the quadrant containing the device much less frequently when it was broadcasting ultrasound. In feeding trials, bats never took a tethered mealworm when the device was delivering sound but often captured mealworms near the device when it was silent. Bats in feeding trials also landed less frequently near the device when it was broadcasting sound but did so more than bats in non-feeding trials. While bats’ avoidance of the device was not absolute, this type of device shows promise in deterring bats from approaching wind turbines.

Evidence of Social Learning in Juvenile and Adult *Eptesicus fuscus*

Genevieve R. Spanjer and Cynthia F. Moss, University of Maryland, College Park, MD

Many bat species are highly gregarious, yet few studies have investigated their capacity for learning from conspecifics, particularly the ability of insectivorous or juvenile bats to learn socially, or if vocal communication might play a role in social learning. We tested whether juvenile and adult *Eptesicus fuscus* could learn a novel foraging task by observing knowledgeable conspecifics. Demonstrator bats were trained to take a tethered mealworm from a string hanging in a flight chamber. Naïve juveniles and adults interacted freely with trained bats daily (one pair at a time) while the trained bat captured and ate 15 mealworms (experimental group; n=8). A control group (n=8) interacted freely with untrained adults with a tethered mealworm present. Naïve bats in both groups were allowed to fly alone with a tethered mealworm present each day following exposure to the other bat. Communicative vocalizations were recorded and analyzed. To date, four bats in the experimental group, compared with no bats in the control group, learned to catch the mealworm successfully in an average of 4.5 days of exposure to a trained bat. Two additional juveniles in the experimental group and three juveniles in the control group directed feeding buzzes toward the mealworm. Unlike any control bats, these two bats in the experimental group also made contact with the worm, knocking it from the string. On average, bats in the control group took longer to emit feeding buzzes while approaching the worm and emitted such buzzes on fewer days than those in the experimental group. Preliminary results indicate that juvenile and adult *E. fuscus* can learn a novel foraging task by observing conspecifics.

Bats, Blood, and Behavior: Addressing Student and Teacher Misconceptions in Elementary Texas Classrooms

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According to research by Mintzes, et.al. (2005), commonly recognized animals are sometimes referred to as charismatic megafauna. The animal of choice for his research was the Bottlenose Dolphin (Tursiops trancatus). The researchers found that these species are misunderstood, even though, on the surface, they appear to be well-known by the general public. Animals such as spiders, snakes, and bats are also the subject of many misconceptions and phobias. These species, from this point forward referred to as “enigmatic shadowfauna”, cause fear and phobias in many people. The physiology of the cardiovascular system in humans and animals has also caused some confusion in elementary teachers, according to research by Palaez et.al. (2005). A survey of questions about bats and the cardiovascular system will be given to three groups: veteran elementary teachers, pre-service teachers, and 3rd and 4th grade elementary students. This research will be developed, distributed, and evaluated by a high school Environmental Systems class. The results will be analyzed to compare background knowledge and the level of misconceptions about bats and the cardiovascular system in the three test groups. After completing the surveys, the three groups will participate in an interactive online videoconference about bats, research, and the cardiovascular system presented by representatives from the eBat Project from Texas A&M University in College Station. A post- presentation survey will be given to a random sample of the original data set immediately following the online training and videoconference.

Radio Telemetry Studies of the Small-footed Bat (*Myotis leibii*) in Pendleton County, West Virginia

Craig W. Stihler, WV Division of Natural Resources, Elkins, WV

Little is known of the life history of *Myotis leibii*, one of the rarest bats in the eastern United States. Previous mist net surveys demonstrated that *M. leibii*, including reproductively active females, could be captured on North Fork Mountain, Pendleton County, WV. Thus, a radio telemetry study was initiated to obtain information on roost sites and, to a lesser extent, foraging habitats. *M. leibii* were radiotracked in either June or July of 1999, 2002, 2004, 2005, and 2006. A total of 12 adult bats (males and pregnant, lactating, post-lactating, and non-reproductive females) were tagged using eyelash adhesive to attach transmitters between the scapulae. Twenty-five roosts were identified, and all were in rock outcroppings or talus. Eight roosts were in extensive cliffs; the exact location of three of these roosts could not be determined. Seventeen roosts were located in talus, most commonly under slabs of rock. Talus roosts were usually in narrow fissures between rocks, perhaps providing some protection from timber rattlesnakes (*Crotalus horridus*) and Allegheny woodrats (*Neotoma magister*) which also inhabit these areas. Most roosts received full or nearly full solar exposure. Roosts that were shaded were used more often by females than males. Roost switching was noted for both male and female bats. Only one bat, a lactating female, was observed roosting with other *M. leibii* (two on one day and three on another). At night, the bats foraged within 2.5 km of their day roosts. Foraging areas were mostly forested, although there were small areas of grassy and old field habitats. The forest was largely dominated by *Quercus* spp. with scattered small patches of forest dominated by *Pinus virginiana*.

Species Identification of Rabid Bats in the United States

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From 1958-2004, 92% (46/50) of indigenously acquired human rabies cases in the United States (U.S.) were associated with insectivorous bats. The eastern pipistrelle (*Perimyotis subflavus*), silver-haired bat (*Lasionycteris noctivagans*), and Brazilian free-tailed bat (*Tadarida brasiliensis*) account for 91% (42/46) of bat-associated cases. The number of bats tested and found rabid in the U.S. has slowly increased between 1998-2004, but on average only 40-60% (e.g., 601 of 989 tested in 1999) of rabid bats are identified to species. Proper identifications of hosts preclude efforts to measure contact rates of bats to humans, and characterize viral reservoirs and spillover of rabies virus among bat species. In this study, we present DNA sequence data on 240 rabid bats in the U.S. from 1997-2005. We sequenced 658bp of the mitochondrial cytochrome oxidase I gene (COI), and used a phylogenetic framework to verify morphological identifications made by state health labs. Of bats assigned to species by state labs, 89.5% (197/220) were correctly identified, 5.9% (13/220) were equivocal, 2.3% (5/220) were incorrect yet identifiable to species, and 2.3% (5/220) were incorrect and not identifiable to species. Of bats assigned *Myotis* sp., 86.7% (13/15) were identifiable to species, and 13.3% (2/15) were equivocal. Of bats lacking identification, 100% (5/5) were identifiable to species.

The molecular data presented can complement identifications made by state health departments, and link spatially and temporally to circulating rabies viral types present in bats.

A Preliminary Comparison of Roost Tree Selection Between Two Species of *Myotis* Living in Sympatry

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Both northern long-eared bats (*Myotis septentrionalis*) and Indiana bats (*M. sodalis*) are rare in southern Michigan, and are known to coexist in only a small number of locations. The Black Creek-River Raisin drainage (Lenawee Co.) represents one of the largest patches of contiguous forest in southeast Michigan, a region dominated by agricultural land use. During summer 2006, we radio-tracked 11 northern long-eared bats to 23 roost trees in the Black Creek-River Raisin drainage. During the same period, we radio-tracked seven Indiana bats to five roost trees within the same drainage. Preliminary examination of the data indicates that northern long-eared bats tended to be more plastic in their roosting preferences, utilizing trees of varying species and decay stages, while Indiana bats tended to use elm (*Ulmus* spp.) and green ash (*Fraxinus pennsylvanica*) in intermediate stages of decay. Northern long-eared bats tended to roost in areas with denser forest and more closed canopies, whereas Indiana bats tended to roost in less densely forested areas in trees with greater solar exposure. Indiana bats traveled greater distances between roosts and switched roosts less frequently than northern long-eared bats. All roost trees were occupied by only one of the species, i.e., no roost overlap was observed.

Dynamics of bat wing membranes during flight

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Bats wings generate aerodynamic forces through the use of forelimbs that possess not only highly specialized gross morphology but also distinctive material characteristics. We demonstrate that the skin of the arm portion of the wing membrane (plagiopatagium) undergoes substantial stretching and recoil in every wingbeat in small flying foxes (*Cynopterus brachyotis*). The deformation is greater in the spanwise than chordwise directions; this parallels the lower spanwise vs. chordwise stiffness, which is, in turn, dictated by the anisotropy of the wing collagen/elastin network of the wing. Wing membrane skin in the distal portions of the wing also deforms during the flight stroke, but to a lower degree than in the plagiopatagium. Building from studies of membrane wing models in a wind tunnel, we hypothesize that the regular, patterned deformation of the wing membrane skin contributes to the maintenance of attached flows at high angles of attack, allowing bat wings to generate significantly more lift than would be possible with a more rigid wing.

An Acoustic Deterrent with the Potential to Reduce Bat Mortality from Wind Turbines

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Widespread and extensive documentation of bat mortality at wind energy facilities indicates a significant threat to many bat populations, particularly when extrapolated out to the number of proposed installations. Any means of deterring bats from approaching these turbines may prevent fatal impacts and reduce bat mortality. We hypothesized that selected regimes of ultrasound could generate an uncomfortable or disorienting airspace that bats would preferentially avoid and that generating such an ultrasound regime around wind turbines can provide an avenue for deterring bats from entering this dangerous airspace. We tested a prototype acoustic deterrent by monitoring foraging activity at eight different pond sites during July and August in CA and OR for two nights to establish baseline activity levels, and then after observing activity similar to baseline on a third night, activating the ultrasonic sound regime. Because the ultrasound regime precluded using acoustic bat detectors, we measured bat activity in the same way each night by counting "visual bat passes" of bats entering and leaving the recorded view from a Sony DCR-TRV520 Nightshot Camera equipped with a high intensity infrared lamp. For the same one hour period each night (20:00 - 21:00), the mean baseline activity was 419 ±153 passes, compared to 238 ±88 passes when the ultrasound regime was active, $P \leq 0.025$. We conclude that ultrasonic broadcasts have promise as a tool for deterring bats. Not surprisingly, bats seemed most affected closer to the ultrasound emitter, suggesting that increasing the amplitude of the sound regime may increase the effectiveness and range of this approach and facilitate scaling this approach up to that required for deterring bats from the airspace surrounding wind turbines.

Water for Wildlife: Improving access and reducing mortality for bats and other wildlife at livestock water developments

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Livestock water developments are often one of the few water sources available to wildlife on arid western rangelands. Bats are especially vulnerable to water shortages, sometimes losing up to 50% of their body weight in evaporative water loss daily. Drinking rates of more than one bat/sec are not uncommon at livestock troughs. Without proper wildlife escape structures and maintenance, significant mortality to bats and other wildlife can occur at livestock troughs. Recent evidence suggests thousands of birds and mammals are drowned annually, including protected species. We evaluated more than 370 livestock troughs from several western states and conducted experiments on the effects of water development configuration and water level on bat access. Although wildlife escape structures are mandatory on most federal rangelands, they were present in <7 percent of the troughs we inspected and >50 percent were obstructed by fencing or bracing. Bats required 3-6 times the number of approaches to successfully drink from troughs with obstructions. The ratio of successful to unsuccessful drinking attempts changed from 2:1 to 1:2 when water levels were lowered by 12" in smaller troughs. Fortunately, wildlife escape structures can be built and installed inexpensively and alternative fencing and bracing methods can facilitate bat access while still meeting livestock management objectives. To address these issues, BCI and the USDI-Natural Resources Conservation Service initiated the Water for Wildlife Project to raise awareness among range and wildlife managers about the importance of livestock waters to bats and other wildlife, to evaluate existing conditions for wildlife at livestock waters, and to publish a comprehensive manual on developing wildlife-friendly livestock waters.

Effectiveness of song cessation by katydids as a defence against gleaning bats

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The katydid *Neoconocephalus ensiger* (Orthoptera) produces an intense calling song. *Myotis septentrionalis*, a gleaning bat, was observed attacking singing *N. ensiger*, and speakers broadcasting their calling song, within an outdoor flight room. *N. ensiger* pauses or ceases singing in response to pulses of ultrasound. The purpose of our study was to test if this response is an effective defense against gleaning bats. Fieldwork was conducted at the Queen's University Biological Station near Kingston, Ontario. Bats (*M. septentrionalis*) were captured in harp traps at local mines. Two speakers were mounted on tripods at one end of a flight room and an infrared sensitive camera and IR light sources were directed towards the speakers. We recorded the responses of the bats to four treatments: either song continued to play from the speaker or the song stopped as the bat attacked, and in both cases a dead katydid was either present or absent on the speaker to provide possible echoic cues. The location of the active speaker and katydid target, and the order of the treatments, was randomized. The bats continued their attack as long as the song was continuous and aborted their attack if the sound stopped as they approached, regardless of whether a katydid target was present. Echolocation call sequences were also analyzed to determine how calls change when passive sound cues stop. Song cessation in response to detecting ultrasound appears to be an effective defense against some gleaning bats.

Home Range and Day Roost Selection of Peter's and Wahlberg's Epauletted Fruit Bats in Kruger National Park, South Africa

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We report the home range, core-use area, and long-axis across home range for 14 *Epomophorus wahlbergi* and 10 *E. crypturus* in Kruger National Park (KNP), South Africa. The mean long axis across home range (3.1 km ± 0.6 S.E.) of *E. crypturus* was significantly larger than that of *E. wahlbergi* (2.3 km ± 0.9 S.E.), however home range and core-use area showed no differences in these species. *Epomophorus wahlbergi* at Skukuza Camp in southern KNP exclusively sheltered under thatch roofs in groups ≤60 bats. In the Shingwedzi River drainage in northern KNP, *E. crypturus* generally roosted near the banks or flood plains of rivers in small trees including the genera *Combretum*, *Maytensus*, *Nuxia*, *Croton*, and *Colophospermum*. Roosting groups at Shingwedzi numbered ≤6 bats and always selected perches less than 4 m above ground. One *E. wahlbergi* was radio-collared during portions of three consecutive years and another in two consecutive years demonstrating that "home range" is fluid in response to the tempo-spatial array of individual fruiting trees. The mean home range for *E. wahlbergi* varied annually; for example mean home range was 38 ± 8.5 ha during an extremely dry year, 2005, but was 10 ± 2.5 ha in 2004, a wet year. The diet of both *E. wahlbergi* and *E. crypturus* was dominated by fruits of *Ficus sycomorus* during all study periods.

Reproductive habits of the Mexican long-nosed bat *Leptonycteris nivalis* (Chiroptera: Phyllostomidae) at "Cueva del Diablo", Tepoztlan Morelos, Mexico

Karla P. Toledo, Luis. A. Caballero, and Rodrigo A. Medellin, UNAM, Mexico, D.F.

Leptonycteris nivalis, the Mexican long-nosed bat, is the largest North American glossophagine bat species. Its distribution is restricted to North America, from south Texas and New Mexico to central Mexico. No detailed study has been conducted on the specific factors that may influence bat abundance and reproduction. However it appears that mating occurs in central Mexico during winter and females occupy northern caves to form maternity colonies in late spring and summer. This basic information is essential for the conservation and management of *L. nivalis*. Certain analysis suggest that the Mexican long-nosed bat has declined in numbers over the past 30 years, probably due to some human activities. Currently this species is listed as Endangered by the IUCN, and as Threatened by the NOM-059 in Mexico. Based on observations and recordings with infrared cameras, we preliminary describe the social structure, mating behavior and reproductive period of *L. nivalis* during its stay in Cueva del Diablo. The Mexican long – nosed bat apparently has a promiscuous mating system conformed by multi-male and multi-female groups, with no evidence of harem or lek formation, territory defense, courtship or marked sexual dimorphism and where apparently mating is not random. Mating period matches the resource availability peak in the zone and it is restricted to the last two weeks of November and first two of December with approximately one month duration.

Long-Term Fidelity of Rafinesque's Big-Eared Bat (*Corynorhinus rafinesquii*) to Bridge Roosts in Southeastern Mississippi

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Roost fidelity of bats is dependent in part on local abundance of roosts. We studied this behavior in a population of Rafinesque's big-eared bat, *Corynorhinus rafinesquii*, in the DeSoto National Forest, Mississippi. We attempted to answer: 1. did marked *C. rafinesquii* move among different roosts or consistently roost at the same location; 2. would *C. rafinesquii* return to previously used roosts where replacement of the bridge had occurred (due to safety concerns). We captured and banded bats (with individually numbered, split plastic rings) as they roosted under bridges from July 2000 through August 2004. We attempted to recapture marked individuals at bridges from July 2000 through May 2005. Of 140 bats (79 females and 61 males) banded, we recaptured 50 (30 females and 20 males), a recovery rate of 36 percent. We recaptured some individuals multiple times; mean number of recaptures per bat was 2.1. In most instances (85 percent) bats were recaptured at their original roost. When bats did move, it was usually to the nearest bridge; the maximum distance between any two sites used by a recaptured bat was 4.1 km. Twenty-seven bats were recaptured within a year of being marked, an additional 12 individuals were recaptured between 1-2 years from their initial capture, and 11 more bats were recaptured >2 years later. Bats returned to seven of 13 sites where bridges had been replaced during the study period. Of potential importance is the fact that the newly constructed bridges were similar in design and dimensions to the original structures. Data suggested sexual differences in interannual fidelity to roosting areas, and we also observed philopatry.

Ecology of the Banana bat, *Musonycteris harrisoni*, in western Mexico

Marco Tschapka, Ellen Sperr, Luis A. Caballero Martínez, and Rodrigo A. Medellin, University of Ulm, Germany; Universidad Nacional Autonoma de Mexico, Mexico

The banana bat is a little-understood, endangered species of nectarivorous bat endemic to Mexico and explored potential reasons for the morphological cranial specialization of this extraordinarily long-snouted bat. What little is known about this species has been produced on the basis of only a few (five at most) individuals. We have studied this species for the past six years in Colima, western Mexico in an area covered by a mixture of tropical dry forest, banana plantations, and coconut plantations. The banana bat coexists with four additional species of nectarivorous bats (*Glossophaga soricina, Anoura geoffroyi, Leptonycteris curasoae*, and *Choeronycteris mexicana*). Among hundreds of nectarivorous bats, we captured 28 *M. harrisoni* in the wet and 30 in the dry season. This represents the largest data set in existence for this species. *Musonycteris harrisoni* uses many food plants with widely differing morphology, but columnar cacti, Ipomoea, Ceiba, Cleome, Pachira, Pseudobombax, Crataeva, Agave and Helicteres are common in the diet. Capture rates for *M. harrisoni* were lowest during the main flowering time of columnar cacti, indicating that the banana plantations support the population mainly during times of low nectar availability of native plants. So far, we found no indication for a tight relationship between *M. harrisoni* and particularly long-tubed flowers that would obligatory require a long rostrum for exploitation. However, we found a significant sexual dimorphism in rostrum length. Males had significantly longer snouts (ca. 9 %) than females, suggesting that the enormously long snout is not necessarily shaped by direct foraging requirements alone, but perhaps also influenced by so-far-unknown intraspecific interactions.

Ecological Relationships of Epauletted Fruit Bats and Sycomore Fig Trees in Kruger National Park, South Africa

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Epauletted fruits bats, *Epomophorus wahlbergi* and *Epomophorus crypturus*, were studied to determine their potential roles as dispersers of *Ficus sycomorus* seeds in Kruger National Park, South Africa. At Skukuza, three newly captured bats were kept in cages for a maximum of three nights. Based on palatal ridge photographs these bats were identified as *E. wahlbergi.* Captives were presented with single ripe figs. The mean weight per fig was 5.4 g (pooled sample), and the mean number of seeds per gram of fig was 44.5 ± 2.8 g. In a single night one bat consumed 29.5 figs (132 g) containing approximately 6500 seeds. Seeds are spit out in pellets of fiber (spats) during feeding, and also are eliminated in feces. Mean time between “spats” was 243 ± 153 s and mean time between defecations was 1207 ± 611 s. At Shingwedzi bats were captured by netting, and radiotransmitters were attached to eleven individuals. These all proved to be *E. crypturus*. Freed bats were radiotracked over a period of twelve nights, and GPS/GIS technology was used to create maps of foraging patterns as the bats fed on sycomore figs. Based on radiotacking data, the cycle time of repeated movements between the fruiting fig tree and the feeding-roost was 314 +/- 116s. During these cycles, feces and spats would fall within a radius of approximately 20 m from the fruiting tree. However, the mean long axis of nightly foraging ranges along gallery forest was 515 +/- 709.8 m. This indicates that bats change feeding venues during the night, creating longer seed dispersal distances in appropriate fig habitat. Thus, cage-study data as well as radiotelemetry data support the hypothesis that epauletted fruit bats play a significant role in the dispersal of *Ficus sycomorus* seeds.

Influence of Modified Water Sources in a Managed Pine Landscape on Bat Foraging Behavior

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Bats forage over large, calm, open bodies of water presumably because insect abundance is high, there are few flight obstacles, and there is low echo interference. Pine plantations in the southeastern United States are economically important and responsible for 60% of timber production in the United States. In coastal North Carolina, a primary landscape aspect of plantation management is presence of heliponds and manmade drainage ditches. Our objective was to determine how water source characteristics in a managed pine landscape affected foraging behavior of bats. We conducted fieldwork during summer 2006 on an intensively managed loblolly pine landscape and on an adjacent natural forested wetland in eastern North Carolina. We used mist netting, remote acoustic sampling, and passive insect trapping to collect data on bat community structure, foraging activity, and diet and insect community structure. We used passive insect traps and full spectrum Pettersson model D240x detectors to sample throughout the night at different water sources. We analyzed echolocation calls for bat species presence and foraging activity and identified insect samples to order. We sampled 10 times each at 5 heliponds, 9 ditches without edges, 14 ditches with edges, and 2 natural forested wetland sites (n = 61 sample sites over 34 nights). Preliminary results suggest that heliponds and managed interior ditches have higher bat abundance relative to unmanaged water sources. *Eptesicus fuscus, Lasiurus borealis, Nycticeius humeralis* were found at all sites while *Myotis* spp. and *Tadarida brasiliensis* were found only over water in unmanaged forest. There appeared to be incomplete overlap in insect orders between modified water and natural wetlands, and there was greater insect abundance in natural forested wetlands. Within the managed forest, heliponds appeared to have greater insect diversity and abundance as compared to other water sources.

Genetic Structure and Historical Demography of the Endangered Indiana Bat (*Myotis sodalis*) as Assessed by mtDNA Analysis of Winter Colonies

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Populations of the endangered Indiana bat (*Myotis sodalis*) have declined dramatically despite extensive conservation efforts. Using mtDNA control region sequences from 314 individuals in 25 winter populations, we assess levels of genetic diversity, and examined the evolutionary relationships, population genetics, and demographic history of *M. sodalis* across their range. With the exception of three populations in New York, overall nucleotide (mean = 0.022) and haplotype (mean h = 0.81) diversities were high. Phylogenetic analyses do not support the presence of reciprocally monophyletic evolutionary lineages, and haplotypes could not be assigned to specific regions. However, we observed significant differences in haplotype frequencies between populations, and distinguished four main population groups (Midwest, Appalachians, and two Northeastern) using nested AMOVAs (25.8% of observed variation among groups, 4.8% among populations within groups, and 69.4% of variation within populations). Despite recent declines, demographic analyses revealed signatures of population expansion in all but one population group, with times since expansion of 1339 and 1741 years bp for the Midwest and Appalachian population groups, respectively. The Northeastern population groups possess low nucleotide and haplotype diversities and were apparently colonized by a small number of individuals within historical times (153 and 270 years bp). The identified population groups are sufficiently distinct genetically to warrant monitoring and conservation as separate units.

Potential of Bats as Predators of Adult Codling Moths (*Cydia pomonella*) in Pear Orchards in California

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Integrated pest management (IPM) programs utilize natural predators to help control the codling moth (*Cydia pomonella*), a major pest of pears. Such predators may include insectivorous bats. To determine the potential of bats as predators of the codling moth, I conducted a study in pear orchards in Fairfield, California, during the summers of 2000 to 2003. Data on bat activity, codling moth activity, and pear damage were collected and analyzed to determine possible relationships between bats and codling moths, and how their activity and pear damage levels could be related to the proximity of an orchard to a local colony of thousands of Mexican free-tailed bats (*T. brasiliensis*). A dietary analysis and population estimates of this large *T. brasiliensis* colony were also conducted. My study determined that bats foraged throughout pear orchards at times when the codling moth was expected to be active. Bat activity remained at similar levels from summer to summer in orchards proximal to the large *T. brasiliensis* colony. Some bats appeared to be attracted to pear orchards when codling moth activity was high. *T. brasiliensis* consumed a high volume of moths when pear damage was high. Yet, codling moth activity and pear damage did not appear to be related to the proximity of an orchard to the large *T. brasiliensis* colony. Species detected and/or captured in orchards included the Mexican free-tailed bat (*T. brasiliensis*), California myotis (*Myotis californicus*), big brown bat (*Eptesicus fuscus*), Yuma myotis (*Myotis yumanensis*), red bat (*Lasiurus blossevillii*), and pallid bat (*Antrozous pallidus*). My study suggests that bat predation of codling moths is occurring, but may not lead to easily detectable reductions in codling moth populations.

Applicability and Reliability of External Survey Techniques when Monitoring for Townsend's Big-eared Bat (*Corynorhinus townsendii*) in Pershing County, Nevada

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During the summer of 2006, 38 mine openings were surveyed for use by bats using a variety of external survey methods. These included a wide range of tools such as TrailMasters, Sony Nightshot cameras with supplement LED's, night vision goggles, a closed-circuit camera system, a remote controlled vehicle, and flood lights. One aspect of this project involved the direct comparison of data collected by Sony Nightshot cameras, night vision, and TrailMasters. We found that each of these tools had value for collecting specific types of data to address different questions. Furthermore, we will discuss the quality and accuracy of data acquired using each of the described methods. We will present specific protocols that maximize the effectiveness of each technique. The applicability of each of these survey methods will be discussed based on the level of survey intensity conducted and the costs associated with each.

Evaluating the Use of Site-Occupancy Modeling to Assess Old-growth Forest Associations of Bats in the Northwestern United States

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Bats have been associated with old-growth forest conditions on the basis of their roost habitat preferences. However, roost habitat represents but one of their ecological needs and it is unclear whether association with old-growth forests is maintained at larger spatial scales. A key provision of the Northwest Forest Plan, which guides management of forests in the northwest United States, is to provide for the persistence of wildlife populations, especially those associated with mature and old-growth forests. Assessing the population status of forest bats, especially at large spatial scales, is difficult. During 2003-2004, I investigated the use of site occupancy patterns as a means of assessing species status at the bio-regional scale, particularly with respect to mature and old-growth forest conditions. Four surveys, which employed a combination of capture and acoustic detection methods, were conducted at each of 51 sample units in northwestern California, western Oregon, and northwestern Washington. I calculated probabilities of site occupancy and detection for 8 species of bats and used sample unit occupancy estimates as a metric for evaluating habitat association. Probabilities of detection ranged from 0.25 for *Myotis evotis* to 0.53 for *M. californicus* and precision of occupancy estimates increased with probability of detection. Two species, *M. thysanodes* and *M. volans*, showed consistent indications of association with mature and old-growth forests. My results suggest that occupancy estimation is an effective means for assessing regional-scale habitat associations, but may require intensive effort for species that are difficult to detect.

Bats of the West Virginia Coalfields

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West Virginia is known for its’ coal and several popular recreational activities, but what may not be as well known is that West Virginia is also home to fourteen (14) species of bats. During the summers of 2003 through 2006, Compliance Monitoring Labs Inc. conducted bat surveys in various locations in southern and western West Virginia. These surveys are required by the United States Fish and Wildlife Service as part of the permitting process. Mist netting was conducted from May to August, in 11 counties of West Virginia. Eight hundred and seventy four bats of nine species, including one endangered species, were netted. Bats were identified and sex, reproductive status, forearm length, and weight, were recorded. All bats were banded and released at the site of capture.

Surprises about Torpor in Bats

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Many endotherms use torpor to save energy during food shortage or harsh weather. Two general trends that have emerged from laboratory and field studies of torpor in bats are: 1) females avoid deep prolonged torpor while reproductive, likely because low temperatures slow offspring growth; and 2) outside of reproduction, use of torpor by small insect-eating bats seems ubiquitous. Here, we report data from two species, each of which defies one of these trends. First, we recorded deep, multi-day torpor in pregnant female hoary bats (*Lasiurus cinereus*, 35 g) from southern Canada. Bouts occurred during spring storms with heavy rain and snow, and lasted 4.3 ± 1.3 days with daily skin temperature minima of 7.6 ± 3.9 °C. When weather improved, females aroused and gave birth within 3.1 ± 1.3 days. This implies a fitness advantage of torpor in addition to energy conservation if low body temperature can delay parturition until favorable conditions for neonatal survival. Second, we obtained laboratory and field data on energetics and torpor in eastern horseshoe bats (*Rhinolophus megaphyllus*, 10 g) from temperate Australia. Despite a small body size and low roost temperature, this species avoids torpor even when non-reproductive. Furthermore, torpid metabolic rate is greater, and therefore energy savings smaller, than predicted based on body mass. Selective costs of torpor other than reproduction, coupled with a tropical evolutionary history, may account for reduced use of torpor in this species. As for many topics in biology, identifying exceptions to trends about thermal biology in bats may improve our understanding of general patterns.

Bats, Birds, Butterflies and Bees: Comparing Patterns of DNA Barcode Sequence Divergence in Flying Life

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Recent work has demonstrated the effectiveness of a standardized segment of the cytochrome c oxidase subunit 1 (CO1) gene as the basis for a species-level identification tool known as “DNA barcoding”. High throughput sequencing efforts are producing a growing database of DNA barcodes and an accompanying body of literature describing patterns of divergence. However, no study to date has reviewed and compared the patterns of sequence diversity in the barcode region across different taxonomic groups. In this investigation, we use available sequences from the Barcode of Life Data Systems website to compare patterns in DNA barcode diversity among four groups of flying animals. We describe the type and position of mutations and base composition variation within the barcode region. In addition, we evaluate success of species identification and the rate of provisional species discovery across these four groups and we compare patterns of barcode diversity at the genus and family level. While an overall pattern of divergence separating species into barcode sequence clusters permits the identification function of DNA barcodes, there are taxon specific characteristics at the amino acid and nucleotide level which reflect unique patterns of sequence evolution. For example, bats and bees share similar overall levels of nucleotide variation, but, in bats, this variation is constrained to synonymous third base substitutions whereas the diversity in bees involves far more amino acid substitutions. While DNA barcoding has been proven as a tool in species identification, this study demonstrates mass data collected as a result of this enterprise will also provide insights into important molecular evolutionary processes.

Bat Activity and Insect Availability in Early Successional Forests: a Preliminary Analysis

Kathryn M. Womack and Alix D. Fink, Longwood University, Farmville, VA

Recent research in the United Kingdom found significant differences in bat use of organic and conventional agricultural land. The elucidated link between vegetation management, insect communities, and bat foraging activity also could apply to managed timber lands. We investigated this potential link in forest stands managed under various regimes to test the hypothesis that bat activity is higher in sites with more plant and, therefore, insect diversity. We conducted this research in the Appomattox-Buckingham State Forest in central Virginia in June-August 2006. We sampled 9 sites representing a continuum from young (0-1 year-old) released loblolly pine plantations to oak shelterwood sites. In each site we established a sampling array consisting of a central bat detector and 4 associated insect trap locations. We assessed bat activity (1930 to 0630 hours) with Anabat II bat detector systems and calculated mean bat passes per hour. We collected insect samples using universal black light traps with photoelectric switches. We dried all samples for 24 hours at 60°C and determined total dry biomass. We assessed vegetation using a 3-m density board to quantify understory characteristics. Here we report the results of a preliminary subsample of bat activity, insect biomass, and vegetation density. Mean bat passes per hour were 7.14 in the youngest pine stands, 5.52 in 3-4 year-old unreleased pine stands, 1.86 in 8-10 year-old post-release pine stands, and 4.30 in oak shelterwood sites. In the continued analysis, we will relate the complete samples of bat activity, insect biomass, and vegetation density to evaluate the proposed relationship. Our goal is to draw conclusions as to bat activity patterns and habitat use in actively managed forest landscapes.

Bat Activity and Diversity in Lowland Forest and Oil Palm Plantations in Peninsular Malaysia

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Malaysia has a significant proportion of all lowland evergreen forest in South East Asia. Bat diversity in these forests is extremely high; however, Malaysia's lowland forest habitats are under increased risk of conversion to oil palm (*Elaeis guineensis*) plantations. Bat species in lowland forest include members of the open space and edge/gap guilds, and possess ecomorphologies that suggests they are more predisposed to exploited areas of agriculture and fragmented habitats. This study investigates the effects of forest conversion to oil palm on bat activity and diversity in Malaysia, hypothesizing a loss of bat species and a reduction in activity in agricultural habitats. A total of 1,087 bats from 28 species were captured using mist nets set at foraging/roost locations. Forearm, weight and wing morphology were measured, and on release individuals were recorded with Anabat and Pettersson detectors to create two call reference libraries. A total of 111 recording nights using both detectors recorded all bat activity in natural tree-fall gaps and rivers (principal foraging habitats for many open space and edge/gap species) and surrounding oil palm. Preliminary results show a significant reduction in bat activity and species diversity in oil palm compared to tree-fall gaps, however, oil palm-forest edge habitat showed similar levels of activity to gap-forest edge. Although many forest interior bats have high frequency, low intensity echolocation, they were often recorded in tree-fall gap habitats. However, as oil palm recording locations became more remote from continuous forest or forest fragments these forest interior bats were no longer recorded. A reduction in bat diversity in these converted habitats may highlight species at a higher risk of extinction.

*Stable-isotope analysis of diet in the short-tailed fruit bats (Chiroptera: Phyllostomidae: Carollia)

Heather A. York and Sharon A. Billings, University of Kansas, Lawrence, KS

*** Heather York** received the **Basically Bats Wildlife Conservation Society Award**

Several species of primarily phytophagous bats are known to feed facultatively on insects, which most likely serve as a protein supplement in high-carbohydrate diets. Initial observations of fecal components of the short-tailed fruit bats (Chiroptera: Phyllostomidae: *Carollia*) suggest that, while it is less prevalent than frugivory, insectivory occurs in these bats. We conducted carbon and nitrogen stable-isotope analyses on fur collected from living individuals and museum specimens from a number of localities throughout Latin America to gain a better understanding of whether insects may comprise a significant proportion of these bats' diets. Nitrogen isotopic data for these species suggest that diets of *C. brevicauda* and *C. subrufa* may include material from trophic levels higher than those consumed by *C. castanea*, *C. perspicillata*, and *C. sowelli*, whose diets are more similar to, but also of a higher trophic level, than those of other frugivorous bats. Carbon isotopic data also indicate that species of *Carollia* feed on organisms whose ultimate food sources are plants with a water balance or, in part, a photosynthetic pathway that differs from those of *Piper*. Isotopic values for both carbon and nitrogen varied by site within species of *Carollia* and tended to differ among species that co-occur at a single site, with some instances of overlap within all pairs of co-occurring species. Although additional studies are needed to confirm the level of insectivory in these frugivorous bats, the present study suggests that it may be an important aspect of dietary behavior in bats typically considered to be exclusively phytophagous.

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Wilmington, North Carolina, 18–21 October 2006

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BOOK REVIEW

Bats of Florida.

Marks, C. S., and G. E. Marks. 2006. University Press of Florida, Gainesville, Florida. U.S.A.
176 pages. ISBN 0-8130-2985-6.

Cynthia and George Marks, co-founders of the Florida Bat Conservancy, have written a book that will be of great interest to educators and others who are fascinated by Florida's diverse bat fauna. The book is organized in 10 chapters and covers basic biology, aspects of natural history, echolocation, general ecology of Florida's bats, individual species accounts, bat conservation, bats in buildings, bat houses, bats and human health, and bat watching. Although generally following the format of similar state guides, it is not clear why the discussion of echolocation was separated from the chapter describing basic biology and why bat houses were not incorporated into the chapter on bat conservation. Nevertheless, the book answers all the questions commonly posed by the public, and this volume would be an excellent reference for someone with only a basic grounding in biology who is developing a presentation on these creatures.

The color photographs of bats in each account are primarily by Scott Altenbach and are, as usual with his work, excellent in quality. However, several photographs show the bat in flight, and though dramatic, they would not be my choice to illustrate characteristics of species such as the gray bat (*Myotis grisescens*) or southeastern bat (*Myotis austroriparius*). Additional black-and-white photographs and line drawings, which are by Tom McOwat, do a good job of demonstrating points made in the text. Nonetheless, there does appear to be one mix-up in the illustrated key to bats on page D-4; although the text indicates that one group of bats has a pointed, furred muzzle while another has a rounded, unfurred muzzle, the drawings appear to show the opposite.

The accounts for the 13 resident and 7 accidental species of bat include paragraphs on physical descriptions, roosting and foraging behavior, reproduction, and geographic range and appropriately include Florida-specific information if available. The specialist will be somewhat disappointed at the lack of detail and absence of references in the species accounts. Those interested in tracking down the source of statements made in the accounts or elsewhere will have to plough through nearly 100 references in the general bibliography, which is organized by author and date rather than by chapter or species.

The account for the Indiana bat (*Myotis sodalis*) includes an assertion that this species has "all but disappeared from its summer range in the northeastern United States," which seems doubtful because recent winter surveys indicated that populations in this area have actually increased. This account and that of *Myotis grisescens* have somewhat misleading statements about the number of hibernacula used by each species, but the authors successfully convey that most of these bats use a small number of caves and are quite vulnerable during winter.

The chapter concerning bats in buildings will be particularly useful to persons answering questions about removing nuisance bats. However, I would have suggested using heavy plastic sheeting, rather than bird netting, as the primary material for constructing a one-way door, because such sheeting is easier to purchase.

Though this book may not be appropriate for readers of *Bat Research News*, other wildlife biologists and the general public will find it to be a useful introduction to bat ecology and the species of the Florida peninsula.

Reviewed by Blake Sasse, Arkansas Game and Fish Commission, Little Rock, AR 72205; dbsasse@agfc.state.ar.us

FUTURE MEETINGS and EVENTS

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

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

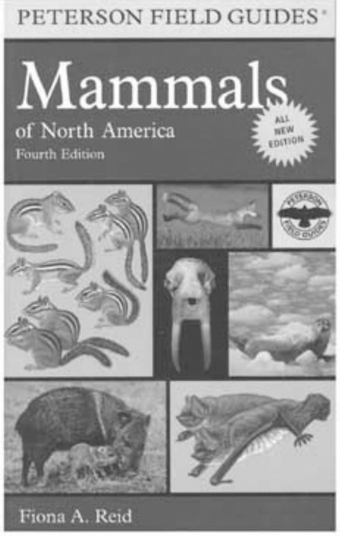
July 29–August 2, 2007
The Cherokee National Forest will host the annual SBDN bat blitz near Roan Mountain/Johnson City, in the Southern Blue Ridge Mountains of northeastern Tennessee. Contact Laura Lewis [lauralewis@fs.fed.usor telephone (423) 476-9752] or see http://www.sbdn.org for information.

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

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

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

ANNOUNCING PUBLICATION
OF AN ALL-NEW
Peterson Field Guide to Mammals of North America



PETERSON FIELD GUIDES®

Mammals

of North America

Fourth Edition

ALL NEW EDITION

Fiona A. Reid

by Fiona A. Reid
now available at bookstores and on-line

A Field Guide to Mammals of North America (paperback, $20) by Fiona A. Reid stands as a shining example of a brilliant author-biologist-artist at work. Rather than attempt a retread of the old Peterson mammal guide, the publisher chose to create an all-new book. Every naturalist will join me in rejoicing that they did. Reid's new guide combines up-to-date life histories, range maps, and taxonomy with skull photos, photographs of selected species in the flesh, and a painting of every mammal in the book. It's a handsome production from start to finish. This will be the definitive North American mammal guide for years to come. *Ed Kanze, All Things Natural*

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Best wishes,
Margaret

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Table of Contents

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